

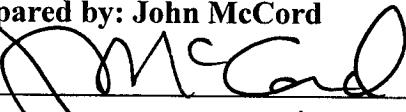
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**Stand Alone DR 39 Package for ANL-WIS-MD-000017 Rev00 ICN01 – Igneous
Consequences Modeling for the TSPA-SR**

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**Stand Alone DR 39 Package for ANL-WIS-MD-000017 Rev00 ICN01 – Igneous
Consequences Modeling for the TSPA-SR
Table of Contents**

1. DR-39 ISSUES	1
2. GENERATION OF PARAMETER DISTRIBUTIONS	1
3. USE OF EXCEL 97-SR-1 in ANL-WIS-MD-000017 Rev00 ICN01	3
3.1 Volume of Ash Erupted CDF	3
3.2 Mean Ash Particle Diameter CDF	6
3.3 Ash Mean Particle Diameter Standard Deviation CDF	11
3.4 Power of Eruption Column CDF	13
3.5 Ash Dispersion Controlling Constant CDF	15
3.6 Initial Eruptive Velocity CDF.....	17
3.7 Wind Speed CDF	20
3.8 Wind Direction PDF	30
3.9 Number of Waste Packages Intersected Per Eruptive Conduit CDF.....	43
3.10 Number of Eruptive Conduits PDF.....	44
3.11 Event Probability CDF.....	47
3.12 Number of Packages Intersected Zone 1 CDF	49
3.13 Number of Packages Intersected – Combined Zone 1 and 2 CDF	49
3.14 CDF for Conduit Diameter	49
4. REFERENCES	53

List of Tables

<u>Table</u>		
		<u>Page</u>
Table 3.1-1	EXCEL values for determining the CDF for Eruptive Volume	4
Table 3.1-2	EXCEL formulae used to generate values shown in Table 3.1-1	5
Table 3.2-1	Sample of the sorted and binned output for the simulation of a triangular distribution defined by -3 (log 0.001 cm) [minimum], -2 (log 0.01 cm) [mode] and -1 (log 0.1 cm) [maximum]	6
Table 3.2-2	EXCEL values for determining the CDF for the log of mean ash particle diameter....	7
Table 3.2-3	EXCEL formulae used to generate values shown in Table 3.2-2	8
Table 3.2-4	EXCEL values for calculation of mean ash particle diameter	9
Table 3.2-5	EXCEL formulae used to generate values shown in Table 3.2-4	10
Table 3.3-1	EXCEL values for determining the CDF for Ash Mean Particle Diameter Standard Deviation.....	11
Table 3.3-2	EXCEL formulae used to generate values shown in Table 3.3-1	12
Table 3.4-1	EXCEL values for determining the CDF for Event Power.....	13
Table 3.4-2	EXCEL formulae used to generate values shown in Table 3.4-1	13
Table 3.5-1	EXCEL values for determining the CDF for Ash Dispersion Controlling Constant (beta).....	15
Table 3.5-2	EXCEL formulae used to generate values shown in Table 3.5-1	16
Table 3.6-1	EXCEL linear least squares calculation values for determining initial eruptive velocities	17
Table 3.6-2	EXCEL formulae used to generate values shown in Table 3.6-1	18
Table 3.6-3	EXCEL calculation values for initial eruptive velocities conditioned on the CDF for conduit (vent) diameter (see Section 3.14 for explanation on development of conduit (vent) diameter CDF).....	18
Table 3.6-4	EXCEL formulae used to generate values shown in Table 3.6-3 (see section 3.14 for explanation on development of conduit (vent) diameter CDF)	19
Table 3.7-1	Wind speed data elevation and associated worksheet name in workbook "Wind_Speed_CDF.xls"	22
Table 3.7-2	Representative portion of EXCEL worksheet containing wind speed data in knots ..	23
Table 3.7-3	Representative portion of EXCEL worksheet containing wind speed data in cm/s ...	24
Table 3.7-4	EXCEL formulae used to generate values shown in Table 3.7-3	25
Table 3.7-5	EXCEL worksheet used to develop wind speed CDF	27
Table 3.7-6	EXCEL formulae used to generate values shown in Table 3.7-5	28
Table 3.8-1	Representative portion of EXCEL worksheet containing Quiring (1968) wind direction data in percent frequency (From Tables 6.1 and 6.2 in Quiring (1968))....	32
Table 3.8-2	EXCEL values for average wind direction for the month of January.....	33
Table 3.8-3	EXCEL formulae used to generate values shown in Table 3.8-2	34
Table 3.8-4	EXCEL values for wind direction averaged over the entire year	36
Table 3.8-5	EXCEL formulae used to generate the values shown in Table 3.8-4	37
Table 3.8-6	EXCEL values for wind direction blowing from in both ASHPLUME and Quiring (1968) coordinates	40
Table 3.8-7	EXCEL values for wind direction PDF	41

List of Tables (Continued)

<u>Table</u>		<u>Page</u>
Table 3.8-8	EXCEL formulae used to generate the values shown in Table 3.8-7	41
Table 3.10-1	Marginal conditional distribution for number of conduits within the Repository Footprint (ANL-MGR-GS-000001 Rev00 ICN01, Table 12a Primary + Contingency Blocks Mean hazard).....	44
Table 3.10-2	EXCEL 97-SR-1 calculation for determining the PDF for Number of Eruptive Conduits Normalized to Remove Probability of Zero Conduits.....	45
Table 3.10-3	EXCEL formulae used to generate values shown in Table 3.10-2	46
Table 3.11-1	A portion of the EXCEL spreadsheet used to normalized the PDF for event probability	47
Table 3.11-2	EXCEL formulae used to generate values shown in Table 3.11-1	47
Table 3.11-3	A portion of the EXCEL spreadsheet used to bin the PDF and calculate the CDF for event probability.....	48
Table 3.11-4	EXCEL formulae used to generate values shown in Table 3.11-3	48
Table 3.14-1	EXCEL values for the PDF and CDF for conduit diameter	50
Table 3.14-2	EXCEL formulae used to generate values shown in Table 3.14-1	51

List of Figures

<u>Figure</u>		<u>Page</u>
Figure 3.1-1	EXCEL-generated figure showing the event eruptive volume CDF.....	5
Figure 3.2-1	EXCEL-generated figure showing the mean ash particle diameter CDF	10
Figure 3.3-1	EXCEL-generated figure showing the Ash Mean Particle Diameter Standard Deviation CDF	12
Figure 3.4-1	EXCEL-generated figure showing the Event Power CDF	14
Figure 3.5-1	EXCEL-generated figure showing the Ash Dispersion Controlling Constant (beta) CDF	16
Figure 3.6-1	EXCEL-generated plot for initial eruptive velocities conditioned on the CDF for conduit diameter.....	19
Figure 3.7-1	EXCEL-generated plot for wind speed CDF	29
Figure 3.8-1	EXCEL-generated wind rose frequency of occurrence diagram for the wind “from” direction in the ASHPLUME coordinate system	42
Figure 3.10-1	EXCEL-generated figure showing the PDF for Number of Eruptive Conduits Normalized to Remove Probability of Zero Conduits PDF.....	46
Figure 3.11-1	EXCEL-generated figure showing the CDF for event probability	48
Figure 3.14-1	EXCEL-generated figure showing the CDF for conduit diameter	52

1. DR-39 ISSUES

Section 3 of the analyses/model report (AMR) ANL-WIS-MD-000017 Rev00 ICN01 – Igneous Consequences Modeling for the TSPA-SR (CRWMS M&O 2000a) states that EXCEL 97-SR-1 was used in the development of input parameters using standard EXCEL functions. It is also stated that some parameters required additional pre or post processing. Following this 10 CDFs and 2 PDFs are listed. However there is no indication as to what EXCEL functions were used, which inputs required pre or post processing, or what that processing was. Section 6 presents a series of figures depicting cumulative distribution functions (CDFs) and probability distribution functions (PDFs) and the text of Section 6 refers to the figures and Attachment I. The figures clearly display the data that is in table form in Attachment I but there is no indication as to how the tables were developed. The figures also reference Data Tracking Number (DTN) SN0010T0502900.003, however, when that DTN is pulled from the Technical Data Tracking System (TDMS) it just contains the same tables of data that are in attachment I. No new information is provided.

It is clear that some functions of EXCEL in combination with some sort of pre and/or post processing were used to go from the data sources listed in Table 2, to the tables in Attachment I and the DTN, and finally to the figures presented in the AMR. What that process was can not be determined from the AMR. The work presented could not be retraced or reproduced without recourse to the author who may no longer be on the project. No spreadsheet cell contents, formulae, or functions used are provided for EXCEL, and there is no description of the pre or post processing steps or even which CDFs or PDFs required pre or post processing. This information needs to be provided for all the CDFs and PDFs listed in Section 3.1 and Attachment I.

This stand alone DR 39 Package for ANL-WIS-MD-000017 Rev00 ICN01 - Igneous Consequences Modeling for the TSPA-SR (CRWMS M&O 2000a) was developed to provide the information needed so that the CDFs and PDFs presented in this AMR can be reproduced without recourse to the AMR author.

2. GENERATION OF PARAMETER DISTRIBUTIONS

Uniform and log-uniform CDF

For a uniform CDF, we note that the cumulative frequency, F , is given by:

$$F = (x-a) / (b-a) \quad (1)$$

where a is the minimum value, b is the maximum value, and x is the value of the random variable. Rearranging this equation, one obtains

$$x = F \times (b-a) + a \quad (2)$$

Thus, knowing a and b , and the desired cumulative probability level, F , the value of the random variable is readily obtained from Eq. (2). In practice, one repeats this calculation at multiple probability levels to generate the full cumulative distribution function (CDF).

For a log-uniform distribution, the extreme values are first converted into logarithmic-space, and the calculated value of the random variable at the desired probability level then back-transformed into real units to yield the required CDF table.

This process was applied for the following variables: (a) eruptive volume, log-uniform with minimum=0.002 km³ and maximum=0.44 km³; (b) ash mean particle diameter standard deviation, uniform distribution, minimum=1 phi unit, maximum=3 phi units; and (c) ash dispersion controlling constant, log uniform distribution, minimum=0.01, maximum=0.5. In all cases, 20 probability levels ranging from 0.0 to 1.0 and 0.05 increments were used to generate the full CDF.

Triangular and log-triangular CDF

The mean ash particle diameter is defined by CRWMS M&O 2000b [ANL-MGR-GS-000002 Rev00, Section 6.5.1] as a log triangular distribution with a minimum value of 0.001 cm, a mode value of 0.01 cm, and a maximum value of 0.1 cm. To develop the PDF and CDF for this parameter using the given specifications, EXCEL 97-SR-1 was used in conjunction with Crystal Ball Version 4.0. Crystal Ball Version 4.0 is a risk analysis program developed to integrate into EXCEL spreadsheets. Crystal Ball uses Monte Carlo simulation to forecast the entire range of results for a given situation. The procedure used to develop the PDF for mean ash particle diameter using Crystal Ball is described in Section 3.2.

Log-normal CDF

One parameter, conduit diameter, is defined as a log-normal distribution with the minimum diameter equal to dike width, the median diameter equal to 50 m, and the maximum diameter equal to 150 m (CRWMS M&O 2000b [ANL-MGR-GS-000002 Rev00, Section 7.0]). Since the dike width parameter itself is defined as a log-normal distribution (CRWMS M&O 2000b [ANL-MGR-GS-000002 Rev00, Section 7.0]), the minimum conduit diameter is assumed to be 4.5 m (CRWMS M&O 2000c [CAL-WIS-PA-000001 Rev01, Section 3.4]).

To develop the PDF and CDF for this parameter using the given specifications, EXCEL 97-SR-1 was used in conjunction with Crystal Ball Version 4.0. Crystal Ball Version 4.0 is a risk analysis program developed to integrate into EXCEL spreadsheets. Crystal Ball uses Monte Carlo simulation to forecast the entire range of results for a given situation. The procedure used to develop the PDF for conduit diameter using Crystal Ball is described in Section 3.14.

3. USE OF EXCEL 97-SR-1

3.1 Volume of Ash Erupted CDF

The range for the event eruptive volume to be expected in the Yucca Mountain area is defined in CRWMS M&O 2000d [ANL-MGR-GS-000001 Rev00 ICN01, Section 6.2 and Table 4] as $0.002 - 0.14 \text{ km}^3$. The NRC IRSR for Igneous Activity, Rev. 2 (Reamer 1999, p. 129) defines an eruptive volume range that spans $0.004 - 0.44 \text{ km}^3$. AMR ANL-WIS-MD-000017 Rev00 ICN01 (CRWMS M&O 2000a) defines the eruptive volume as a log-uniform distribution that spans the range defined by combining these two ranges ($0.002 - 0.44 \text{ km}^3$). The specified range incorporates both the IRSR range and the range from CRWMS M&O 2000d [ANL-MGR-GS-000001 Rev00 ICN01]. The calculation approach for a log-uniform distribution was employed using EXCEL 97-SR-1 to develop the CDF for event eruptive volume.

First EXCEL was used to determine the log of the extreme values (0.002 km^3 and 0.44 km^3) which corresponds to the CDF values of 0 and 1.0 respectively. To fill out the CDF, the analyst chose to divide the CDF into 20 steps or 0.05 frequency increments. Table 3.1-1 shows the EXCEL values. Table 3.1-2 shows the EXCEL cell formulae used to generate the value table.

Table 3.1-1 – EXCEL values for determining the CDF for Eruptive Volume

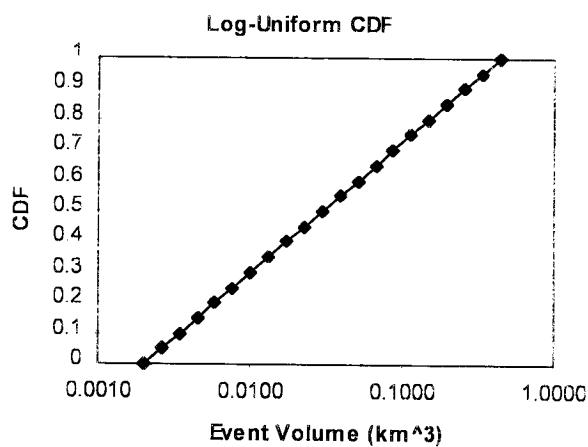
Event Volume (Log-Uniform CDF)

COLUMN> ROW	A log(Volume)	B Volume (km ³)	C CDF
5	-2.699	0.0020	0
6	-2.582	0.0026	0.05
7	-2.465	0.0034	0.1
8	-2.348	0.0045	0.15
9	-2.230	0.0059	0.2
10	-2.113	0.0077	0.25
11	-1.996	0.0101	0.3
12	-1.879	0.0132	0.35
13	-1.762	0.0173	0.4
14	-1.645	0.0227	0.45
15	-1.528	0.0297	0.5
16	-1.411	0.0388	0.55
17	-1.294	0.0509	0.6
18	-1.176	0.0666	0.65
19	-1.059	0.0872	0.7
20	-0.942	0.1142	0.75
21	-0.825	0.1496	0.8
22	-0.708	0.1959	0.85
23	-0.591	0.2566	0.9
24	-0.474	0.3360	0.95
25	-0.357	0.4400	1.0

Table 3.1-2 - EXCEL formulae used to generate values shown in Table 3.1-1

log(Volume)	Volume (km ³)	CDF
=LOG(B5)	0.002	0
=A5+(A\$25-A\$5)/20	=10^A6	=C5+0.05
=A6+(A\$25-A\$5)/20	=10^A7	=C6+0.05
=A7+(A\$25-A\$5)/20	=10^A8	=C7+0.05
=A8+(A\$25-A\$5)/20	=10^A9	=C8+0.05
=A9+(A\$25-A\$5)/20	=10^A10	=C9+0.05
=A10+(A\$25-A\$5)/20	=10^A11	=C10+0.05
=A11+(A\$25-A\$5)/20	=10^A12	=C11+0.05
=A12+(A\$25-A\$5)/20	=10^A13	=C12+0.05
=A13+(A\$25-A\$5)/20	=10^A14	=C13+0.05
=A14+(A\$25-A\$5)/20	=10^A15	=C14+0.05
=A15+(A\$25-A\$5)/20	=10^A16	=C15+0.05
=A16+(A\$25-A\$5)/20	=10^A17	=C16+0.05
=A17+(A\$25-A\$5)/20	=10^A18	=C17+0.05
=A18+(A\$25-A\$5)/20	=10^A19	=C18+0.05
=A19+(A\$25-A\$5)/20	=10^A20	=C19+0.05
=A20+(A\$25-A\$5)/20	=10^A21	=C20+0.05
=A21+(A\$25-A\$5)/20	=10^A22	=C21+0.05
=A22+(A\$25-A\$5)/20	=10^A23	=C22+0.05
=A23+(A\$25-A\$5)/20	=10^A24	=C23+0.05
=LOG(B25)	0.44	1

Figure 3.1-1 - EXCEL-generated figure showing the event eruptive volume CDF.



3.2 Mean Ash Particle Diameter CDF

The mean ash particle diameter for the volcanic eruption vent is defined by CRWMS M&O 2000b [ANL-MGR-GS-000002 Rev00, Section 6.5.1] as a log triangular distribution with a minimum value of 0.001 cm, a mode value of 0.01 cm, and a maximum value of 0.1 cm. The calculation approach used Crystal Ball Version 4 as a pre-processor to simulate a frequency distribution within the specified log-triangular distribution, and then used EXCEL 97-SR-1 to bin the results and calculate the PDF and CDF for mean ash particle diameter.

To generate a frequency distribution, the triangular distribution was selected from the Crystal Ball Version 4 Distribution Gallery. The required input for the triangular distribution is a minimum value, the likeliest value (mode) and a maximum value. To simulate the frequency distribution for the specified log-triangular distribution the input values were -3 (log 0.001 cm) [minimum], -2 (log 0.01 cm) [mode] and -1 (log 0.1 cm) [maximum]. The output from the simulation was 9,000 random values that conform to the specified distribution. EXCEL was then used to sort and bin the simulation output. Table 3.2-1 shows a portion of the sorted and binned simulation output.

Table 3.2-1 – Sample of the sorted and binned output for the simulation of a triangular distribution defined by -3 (log 0.001 cm) [minimum], -2 (log 0.01 cm) [mode] and -1 (log 0.1 cm) [maximum].

COLUMN > ROW	G Start Value	H End Value	I Frequency
3	-Infinity	-3.00	0
4	-3.00	-2.98	3
5	-2.98	-2.96	0
6	-2.96	-2.94	3
7	-2.94	-2.92	20
8	-2.92	-2.90	16
9	-2.90	-2.88	10
10	-2.88	-2.86	33
11	-2.86	-2.84	26
12	-2.84	-2.82	38
13	-2.82	-2.80	33
14	-2.80	-2.78	43
15	-2.78	-2.76	51
16	-2.76	-2.74	45
17	-2.74	-2.72	48
18	-2.72	-2.70	48
19	-2.70	-2.68	54
20	-2.68	-2.66	62
21	-2.66	-2.64	58
22	-2.64	-2.62	64
23	-2.62	-2.60	71
24	-2.60	-2.58	53

EXCEL was then used to bin the simulated values and calculate the PDF and CDF for the log of the mean ash particle diameter. Table 3.2-2 shows the EXCEL values for these calculations. Table 3.2-3 shows the EXCEL cell formulae used to generate the value table.

Table 3.2-2 - EXCEL values for determining the CDF for the log of mean ash particle diameter

COLUMN > ROW	K	L	M	N	O	P	Q	
					Normalized			
3		Start Value	End Value	Average Value	Frequency	Frequency	PDF	CDF
4	-3	-3	-2.9	-2.95	42	44.5	0.0049	0.0049
5	-2.9	-2.9	-2.8	-2.85	140	140	0.0156	0.0205
6	-2.8	-2.8	-2.7	-2.75	235	231.5	0.0257	0.0462
7	-2.7	-2.7	-2.6	-2.65	309	302	0.0336	0.0798
8	-2.6	-2.6	-2.5	-2.55	385	395.5	0.0439	0.1237
9	-2.5	-2.5	-2.4	-2.45	472	486.5	0.0541	0.1778
10	-2.4	-2.4	-2.3	-2.35	581	570.5	0.0634	0.2412
11	-2.3	-2.3	-2.2	-2.25	647	687	0.0763	0.3175
12	-2.2	-2.2	-2.1	-2.15	764	791.5	0.0879	0.4054
13	-2.1	-2.1	-2	-2.05	852	851	0.0946	0.5000
14	-2	-2	-1.9	-1.95	850	851	0.0946	0.5946
15	-1.9	-1.9	-1.8	-1.85	819	791.5	0.0879	0.6825
16	-1.8	-1.8	-1.7	-1.75	727	687	0.0763	0.7588
17	-1.7	-1.7	-1.6	-1.65	560	570.5	0.0634	0.8222
18	-1.6	-1.6	-1.5	-1.55	501	486.5	0.0541	0.8763
19	-1.5	-1.5	-1.4	-1.45	406	395.5	0.0439	0.9202
20	-1.4	-1.4	-1.3	-1.35	295	302	0.0336	0.9538
21	-1.3	-1.3	-1.2	-1.25	228	231.5	0.0257	0.9795
22	-1.2	-1.2	-1.1	-1.15	140	140	0.0156	0.9951
23	-1.1	-1.1	-1	-1.05	47	44.5	0.0049	1.0000
24	-1	-1	-1	-1	0	0	0.0000	1.0000
25								
26					9000	9000	1	

Table 3.2-3 - EXCEL formulae used to generate values shown in Table 3.2-2

COLUMN > ROW	K	L	M	N	O	P	Q
	Start Value	End Value	Average Value	Frequency	Normalized Frequency	PDF	CDF
3		-3	-3	=I3	=(N3+N24)/2	=O3/\$O\$26	=P3
4	-3	-2.9	=(K4+L4)/2	=SUM(I4:I8)	=(N4+N23)/2	=O4/\$O\$26	=P4+Q3
5	=K4+0.1	=L4+0.1	=(K5+L5)/2	=SUM(I9:I13)	=(N5+N22)/2	=O5/\$O\$26	=P5+Q4
6	=K5+0.1	=L5+0.1	=(K6+L6)/2	=SUM(I14:I18)	=(N6+N21)/2	=O6/\$O\$26	=P6+Q5
7	=K6+0.1	=L6+0.1	=(K7+L7)/2	=SUM(I19:I23)	=(N7+N20)/2	=O7/\$O\$26	=P7+Q6
8	=K7+0.1	=L7+0.1	=(K8+L8)/2	=SUM(I24:I28)	=(N8+N19)/2	=O8/\$O\$26	=P8+Q7
9	=K8+0.1	=L8+0.1	=(K9+L9)/2	=SUM(I29:I33)	=(N9+N18)/2	=O9/\$O\$26	=P9+Q8
10	=K9+0.1	=L9+0.1	=(K10+L10)/2	=SUM(I34:I38)	=(N10+N17)/2	=O10/\$O\$26	=P10+Q9
11	=K10+0.1	=L10+0.1	=(K11+L11)/2	=SUM(I39:I43)	=(N11+N16)/2	=O11/\$O\$26	=P11+Q10
12	=K11+0.1	=L11+0.1	=(K12+L12)/2	=SUM(I44:I48)	=(N12+N15)/2	=O12/\$O\$26	=P12+Q11
13	=K12+0.1	=L12+0.1	=(K13+L13)/2	=SUM(I49:I53)	=(N13+N14)/2	=O13/\$O\$26	=P13+Q12
14	=K13+0.1	=L13+0.1	=(K14+L14)/2	=SUM(I54:I58)	=(N14+N13)/2	=O14/\$O\$26	=P14+Q13
15	=K14+0.1	=L14+0.1	=(K15+L15)/2	=SUM(I59:I63)	=(N15+N12)/2	=O15/\$O\$26	=P15+Q14
16	=K15+0.1	=L15+0.1	=(K16+L16)/2	=SUM(I64:I68)	=(N16+N11)/2	=O16/\$O\$26	=P16+Q15
17	=K16+0.1	=L16+0.1	=(K17+L17)/2	=SUM(I69:I73)	=(N17+N10)/2	=O17/\$O\$26	=P17+Q16
18	=K17+0.1	=L17+0.1	=(K18+L18)/2	=SUM(I74:I78)	=(N18+N9)/2	=O18/\$O\$26	=P18+Q17
19	=K18+0.1	=L18+0.1	=(K19+L19)/2	=SUM(I79:I83)	=(N19+N8)/2	=O19/\$O\$26	=P19+Q18
20	=K19+0.1	=L19+0.1	=(K20+L20)/2	=SUM(I84:I88)	=(N20+N7)/2	=O20/\$O\$26	=P20+Q19
21	=K20+0.1	=L20+0.1	=(K21+L21)/2	=SUM(I89:I93)	=(N21+N6)/2	=O21/\$O\$26	=P21+Q20
22	=K21+0.1	=L21+0.1	=(K22+L22)/2	=SUM(I94:I98)	=(N22+N5)/2	=O22/\$O\$26	=P22+Q21
23	=K22+0.1	=L22+0.1	=(K23+L23)/2	=SUM(I99:I103)	=(N23+N4)/2	=O23/\$O\$26	=P23+Q22
24	-1		-1	=I104	=(N24+N3)/2	=O24/\$O\$26	=P24+Q23
25							
26				=SUM(N3:N24)	=SUM(O3:O24)	=SUM(P3:P24)	

Finally, EXCEL was used to calculate the mean ash particle diameter from the log values. Table 3.2-4 shows the EXCEL values for this calculation and the CDF for these values and Table 3.2-5 shows the EXCEL formulae for the calculation.

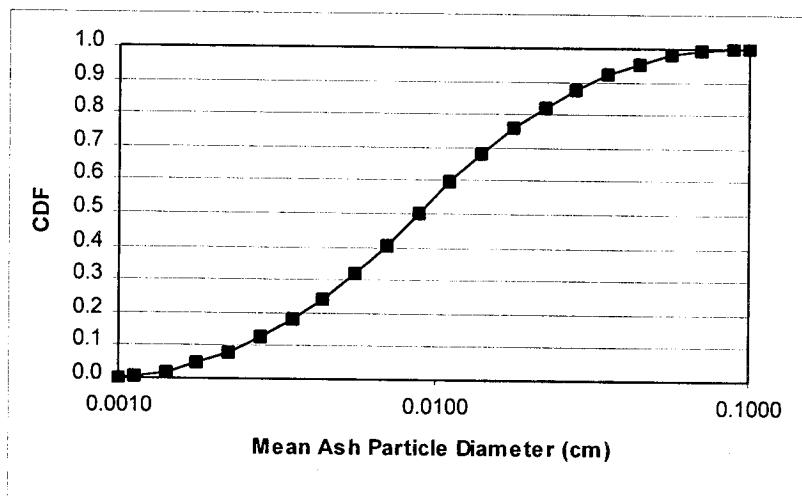
Table 3.2-4 – EXCEL values for calculation of mean ash particle diameter

COLUMN >	S	T	U
ROW	Log Value	Value	CDF
3	-3	0.0010	0.0000
4	-2.95	0.0011	0.0049
5	-2.85	0.0014	0.0205
6	-2.75	0.0018	0.0462
7	-2.65	0.0022	0.0798
8	-2.55	0.0028	0.1237
9	-2.45	0.0035	0.1778
10	-2.35	0.0045	0.2412
11	-2.25	0.0056	0.3175
12	-2.15	0.0071	0.4054
13	-2.05	0.0089	0.5000
14	-1.95	0.0112	0.5946
15	-1.85	0.0141	0.6825
16	-1.75	0.0178	0.7588
17	-1.65	0.0224	0.8222
18	-1.55	0.0282	0.8763
19	-1.45	0.0355	0.9202
20	-1.35	0.0447	0.9538
21	-1.25	0.0562	0.9795
22	-1.15	0.0708	0.9951
23	-1	0.1000	1.0000

Table 3.2-5 – EXCEL formulae used to generate values shown in Table 3.2-4

COLUMN>	S	T	U
ROW	Log Value	Value	CDF
3	-3	=10^S3	0
4	-2.95	=10^S4	0.00494
5	-2.85	=10^S5	0.02050
6	-2.75	=10^S6	0.04622
7	-2.65	=10^S7	0.07977
8	-2.55	=10^S8	0.12372
9	-2.45	=10^S9	0.17777
10	-2.35	=10^S10	0.24116
11	-2.25	=10^S11	0.3175
12	-2.15	=10^S12	0.40544
13	-2.05	=10^S13	0.5
14	-1.95	=10^S14	0.59455
15	-1.85	=10^S15	0.6825
16	-1.75	=10^S16	0.75883
17	-1.65	=10^S17	0.82222
18	-1.55	=10^S18	0.87627
19	-1.45	=10^S19	0.92022
20	-1.35	=10^S20	0.95377
21	-1.25	=10^S21	0.9795
22	-1.15	=10^S22	0.99505
23	-1	=10^S23	1

Figure 3.2-1 - EXCEL-generated figure showing the mean ash particle diameter CDF.



3.3 Ash Mean Particle Diameter Standard Deviation CDF

The ash mean particle standard deviation is provided in CRWMS M&O 2000b (ANL-MGR-GS-000002 Rev00, Section 6.5.1) as a uniform distribution from 1-3 (phi units, which are defined to be the negative logarithm in base 2 of the particle diameter in millimeters). The calculation approach for a uniform distribution was employed using EXCEL 97-SR-1 to develop the CDF for the mean ash particle diameter standard deviation.

A uniform distribution between the extreme values (1.0 – 3.0 phi units) was developed using EXCEL. To fill out the CDF, the analyst chose to divide the CDF into 20 steps or 0.05 frequency increments. Table 3.3-1 shows the EXCEL values. Table 3.3-2 shows the EXCEL cell formulae used to generate the value table.

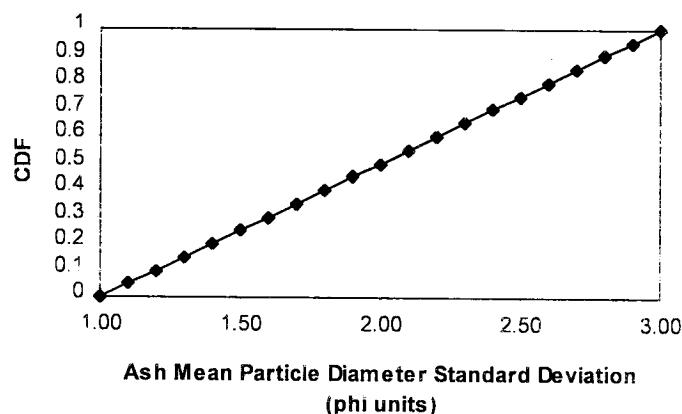
Table 3.3-1 - EXCEL values for determining the CDF for Ash Mean Particle Diameter Standard Deviation

COLUMN> ROW	A Sigma (Phi Units)	B CDF
5	1.00	0
6	1.10	0.05
7	1.20	0.1
8	1.30	0.15
9	1.40	0.2
10	1.50	0.25
11	1.60	0.3
12	1.70	0.35
13	1.80	0.4
14	1.90	0.45
15	2.00	0.5
16	2.10	0.55
17	2.20	0.6
18	2.30	0.65
19	2.40	0.7
20	2.50	0.75
21	2.60	0.8
22	2.70	0.85
23	2.80	0.9
24	2.90	0.95
25	3.00	1.0

Table 3.3-2 - EXCEL formulae used to generate values shown in Table 3.3-1

Sigma (Phi Units)	CDF
1	=B5+0.05
=A5+(A\$25-A\$5)/20	=B5+0.05
=A6+(A\$25-A\$5)/20	=B6+0.05
=A7+(A\$25-A\$5)/20	=B7+0.05
=A8+(A\$25-A\$5)/20	=B8+0.05
=A9+(A\$25-A\$5)/20	=B9+0.05
=A10+(A\$25-A\$5)/20	=B10+0.05
=A11+(A\$25-A\$5)/20	=B11+0.05
=A12+(A\$25-A\$5)/20	=B12+0.05
=A13+(A\$25-A\$5)/20	=B13+0.05
=A14+(A\$25-A\$5)/20	=B14+0.05
=A15+(A\$25-A\$5)/20	=B15+0.05
=A16+(A\$25-A\$5)/20	=B16+0.05
=A17+(A\$25-A\$5)/20	=B17+0.05
=A18+(A\$25-A\$5)/20	=B18+0.05
=A19+(A\$25-A\$5)/20	=B19+0.05
=A20+(A\$25-A\$5)/20	=B20+0.05
=A21+(A\$25-A\$5)/20	=B21+0.05
=A22+(A\$25-A\$5)/20	=B22+0.05
=A23+(A\$25-A\$5)/20	=B23+0.05
3	1

Figure 3.3-1 - EXCEL-generated figure showing the Ash Mean Particle Diameter Standard Deviation CDF.



3.4 Power of Eruption Column CDF

The event power is provided by CRWMS M&O 2000b (ANL-MGR-GS-000002 Rev00, Section 6.3.4 and Table 5). The eruptive power for eight representative events is utilized to form a CDF. These eight events span the range of events that could be expected at Yucca Mountain. A CDF is formed using EXCEL 97-SR-1 from these eight events assuming that the power of each identified is equally likely to occur. Thus each representative event is equally weighted by the CDF weighting factor (CDF WF).

Table 3.4-1 shows the EXCEL values. Table 3.4-2 shows the EXCEL cell formulae used to generate the value table.

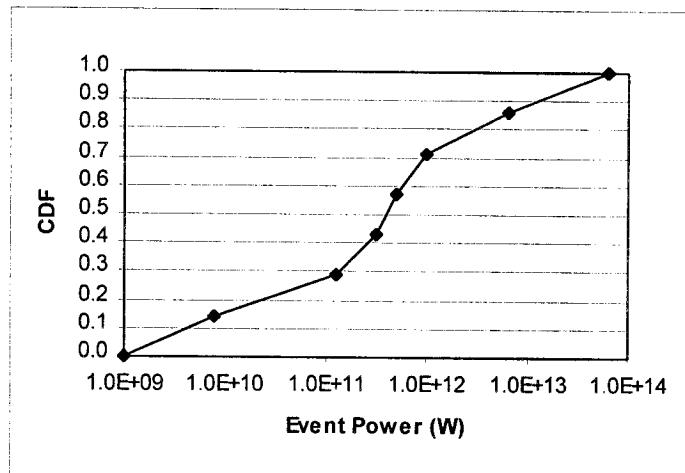
Table 3.4-1 - EXCEL values for determining the CDF for Event Power

COLUMN>	A	B	C	D
ROW	Log Power (W)	Power (W)	CDF WF	CDF
4	9.0	1.000E+09	0.143	0.000
5	9.9	7.943E+09	0.143	0.143
6	11.1	1.259E+11	0.143	0.286
7	11.5	3.162E+11	0.143	0.429
8	11.7	5.012E+11	0.143	0.571
9	12.0	1.000E+12	0.143	0.714
10	12.8	6.310E+12	0.143	0.857
11	13.8	6.310E+13	0.143	1.000

Table 3.4-2 - EXCEL formulae used to generate values shown in Table 3.4-1

COLUMN >	A	B	C	D
ROW	Log Power (W)	Power (W)	CDF WF	CDF
4	9	=10^A4	=1/7	0
5	9.9	=10^A5	=1/7	=D4+C5
6	11.1	=10^A6	=1/7	=D5+C6
7	11.5	=10^A7	=1/7	=D6+C7
8	11.7	=10^A8	=1/7	=D7+C8
9	12	=10^A9	=1/7	=D8+C9
10	12.8	=10^A10	=1/7	=D9+C10
11	13.8	=10^A11	=1/7	=D10+C11

Figure 3.4-1 - EXCEL-generated figure showing the Event Power CDF.



3.5 Ash Dispersion Controlling Constant CDF

The ash dispersion controlling constant (beta) is assumed to have a log-uniform distribution that has a minimum value of 0.01 and a maximum value of 0.5 CRWMS M&O 2000a (ANL-WIS-MD-000017 Rev00 ICN01, Section 5.4.6).

The calculation approach for a log-uniform distribution was employed using EXCEL 97-SR-1 to develop the CDF for event eruptive volume. First EXCEL was used to determine the log of the extreme values (0.01 and 0.5) which corresponds to the CDF values of 0 and 1.0 respectively. To fill out the CDF, the analyst chose to divide the CDF into 20 steps or 0.05 frequency increments. Table 3.5-1 shows the EXCEL values. Table 3.5-2 shows the EXCEL cell formulae used to generate the value table.

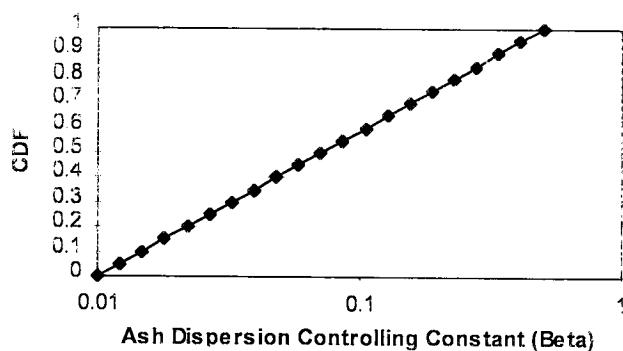
Table 3.5-1 – EXCEL values for determining the CDF for Ash Dispersion Controlling Constant (beta)

COLUMN> ROW	A log(Beta)	B Beta	C CDF
5	-2.000	0.01	0
6	-1.915	0.012	0.05
7	-1.830	0.015	0.1
8	-1.745	0.018	0.15
9	-1.660	0.022	0.2
10	-1.575	0.027	0.25
11	-1.490	0.032	0.3
12	-1.405	0.039	0.35
13	-1.320	0.048	0.4
14	-1.235	0.058	0.45
15	-1.151	0.071	0.5
16	-1.066	0.086	0.55
17	-0.981	0.105	0.6
18	-0.896	0.127	0.65
19	-0.811	0.155	0.7
20	-0.726	0.188	0.75
21	-0.641	0.229	0.8
22	-0.556	0.278	0.85
23	-0.471	0.338	0.9
24	-0.386	0.411	0.95
25	-0.301	0.500	1.0

Table 3.5-2 - EXCEL formulae used to generate values shown in Table 3.5-1

COLUMN >	A	B	C
ROW	log(Beta)	Beta	CDF
5	=LOG(B5)	0.01	0
6	=A5+(A\$25-A\$5)/20	=10^A6	=C5+0.05
7	=A6+(A\$25-A\$5)/20	=10^A7	=C6+0.05
8	=A7+(A\$25-A\$5)/20	=10^A8	=C7+0.05
9	=A8+(A\$25-A\$5)/20	=10^A9	=C8+0.05
10	=A9+(A\$25-A\$5)/20	=10^A10	=C9+0.05
11	=A10+(A\$25-A\$5)/20	=10^A11	=C10+0.05
12	=A11+(A\$25-A\$5)/20	=10^A12	=C11+0.05
13	=A12+(A\$25-A\$5)/20	=10^A13	=C12+0.05
14	=A13+(A\$25-A\$5)/20	=10^A14	=C13+0.05
15	=A14+(A\$25-A\$5)/20	=10^A15	=C14+0.05
16	=A15+(A\$25-A\$5)/20	=10^A16	=C15+0.05
17	=A16+(A\$25-A\$5)/20	=10^A17	=C16+0.05
18	=A17+(A\$25-A\$5)/20	=10^A18	=C17+0.05
19	=A18+(A\$25-A\$5)/20	=10^A19	=C18+0.05
20	=A19+(A\$25-A\$5)/20	=10^A20	=C19+0.05
21	=A20+(A\$25-A\$5)/20	=10^A21	=C20+0.05
22	=A21+(A\$25-A\$5)/20	=10^A22	=C21+0.05
23	=A22+(A\$25-A\$5)/20	=10^A23	=C22+0.05
24	=A23+(A\$25-A\$5)/20	=10^A24	=C23+0.05
25	=LOG(B25)	0.5	1

Figure 3.5-1 - EXCEL-generated figure showing the Ash Dispersion Controlling Constant (beta) CDF.



3.6 Initial Eruptive Velocity CDF

Initial eruptive velocity is addressed in CRWMS M&O 2000a (ANL-WIS-MD-000017 Rev00 ICN01 in Section 5.4.7). In this discussion, the initial eruptive velocity of the eruptive event is defined from Wilson and Head (1981, p. 2977) as a function of the conduit radius. Table 3 of Wilson and Head (1981, p. 2977) shows a nearly linear relationship between the conduit radius and the initial eruption velocity for conduit radii of 0.2 – 30 meters (conduit diameters of 0.4 – 60 m) and eruptive velocities of 0.033 – 86.2 m/s. AMR ANL-WIS-MD-000017 Rev00 ICN01 (CRWMS M&O 2000a) utilizes conduit diameters up to 150 meters (CRWMS M&O 2000b [ANL-MGR-GS-000002 Rev00, Section 6.1]).

A linear least squares regression hand calculation on the data from Wilson and Head was done and the resulting linear equation extrapolated up to a 75 m conduit radii (150-meter conduit (vent) diameter). This linear extrapolation of the treatment of the initial eruptive velocity is a reasonable engineering treatment of the available information and allows the anticipated range of values of conduit (vent) diameter to be captured. The resulting eruptive velocities were conditioned on the CDF for conduit diameter that is discussed in Section 3.14.

Table 3.6-1 - EXCEL linear least squares calculation values for determining initial eruptive velocities

V	W	X	Y	Z	AA	AB
3				$y=bx+a$		
4				b	148.87363	
5	x	y		a	-37.043764	
6	Vent	Eruption	Regression Fit			
7	Diameter (m)	Velocity (cm/s)	xi-xmean	(xi-xmean)^2	yi-ymean	(xi-xmean)*(yi-ymean)
8	0.4	3.3	-11.025	121.550625	-1660.5375	18307.42594
9	0.6	7.4	-10.825	117.180625	-1656.4375	17930.93594
10	1	20	-10.425	108.680625	-1643.8375	17137.00594
11	1.4	40	-10.025	100.500625	-1623.8375	16278.97094
12	2	80	-9.425	88.830625	-1583.8375	14927.66844
13	6	690	-5.425	29.430625	-973.8375	5283.068438
14	20	3850	8.575	73.530625	2186.1625	18746.34344
15	60	8620	48.575	2359.530625	6956.1625	337895.5934
16	mean	11.425	1663.8375	sum	2999.235	446507.0125

Table 3.6-2 - EXCEL formulae used to generate values shown in Table 3.6-1

V	W	X	Y	Z	AA	AB
3				$y=bx+a$		
4				b	=AB16/Z16	
5	x	y	Regression Fit	a	=X16-AA4*W16	
6	Vent	Eruption				
7	Diameter (m)	Velocity (cm/s)	xi-xmean	(xi-xmean)^2	yi-ymean	$(xi-xmean)*(yi-ymean)$
8	0.4	3.3	=W8-\$W\$16	=Y8*Y8	=X8-\$X\$16	=Y8*AA8
9	0.6	7.4	=W9-\$W\$16	=Y9*Y9	=X9-\$X\$16	=Y9*AA9
10	1	20	=W10-\$W\$16	=Y10*Y10	=X10-\$X\$16	=Y10*AA10
11	1.4	40	=W11-\$W\$16	=Y11*Y11	=X11-\$X\$16	=Y11*AA11
12	2	80	=W12-\$W\$16	=Y12*Y12	=X12-\$X\$16	=Y12*AA12
13	6	690	=W13-\$W\$16	=Y13*Y13	=X13-\$X\$16	=Y13*AA13
14	20	3850	=W14-\$W\$16	=Y14*Y14	=X14-\$X\$16	=Y14*AA14
15	60	8620	=W15-\$W\$16	=Y15*Y15	=X15-\$X\$16	=Y15*AA15
16 mean	=AVERAGE(W8:W15)	=AVERAGE(X8:X15)	sum 5)	=SUM(Z8:Z15)		=SUM(AB8:AB15)

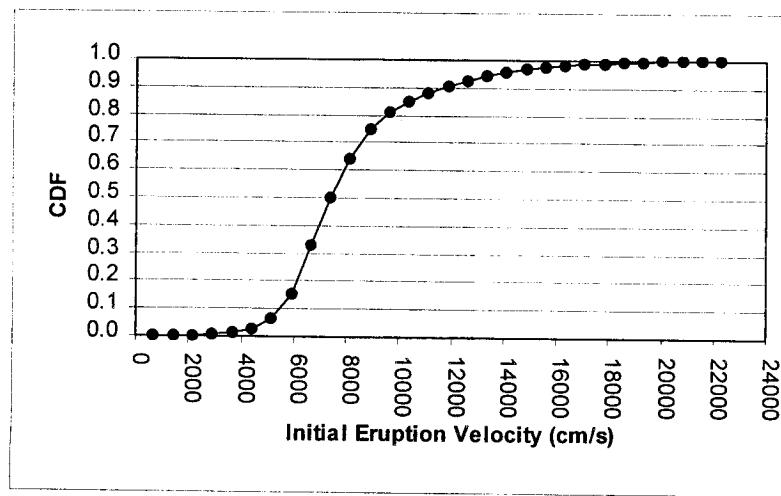
Table 3.6-3 - EXCEL calculation values for initial eruptive velocities conditioned on the CDF for conduit (vent) diameter (see Section 3.14 for explanation on development of conduit (vent) diameter CDF)

ROW	Column		
	W	X	
	Vent	Eruption	
	Diameter (m)	Velocity (cm/s)	CDF
22	0.4	22.5	
23	4.5	633	0.0000
24	10	1452	0.0004
25	15	2196	0.0022
26	20	2940	0.0066
27	25	3685	0.0145
28	30	4429	0.0277
29	35	5174	0.0623
30	40	5918	0.1541
31	45	6662	0.3262
32	50	7407	0.5008
33	55	8151	0.6413
34	60	8895	0.7467
35	65	9640	0.8082
36	70	10384	0.8477
37	75	11128	0.8776
38	80	11873	0.9026
39	85	12617	0.9237
40	90	13362	0.9412
41	95	14106	0.9549
42	100	14850	0.9654
43	105	15595	0.9733
44	110	16339	0.9799
45	115	17083	0.9853
46	120	17828	0.9897
47	125	18572	0.9933
48	130	19317	0.9960
49	135	20061	0.9978
50	140	20805	0.9989
51	145	21550	0.9996
52	150	22294	1.0000

Table 3.6-4 – EXCEL formulae used to generate values shown in Table 3.6-3 (see section 3.14 for explanation on development of conduit (vent) diameter CDF)

ROW	Vent	Eruption	CDF
	Diameter (m)	Velocity (cm/s)	
22	0.4	=W22*\$AA\$4+\$AA\$5	
23	4.5	=W23*\$AA\$4+\$AA\$5	0
24	10	=W24*\$AA\$4+\$AA\$5	0.00043909721612365
25	15	=W25*\$AA\$4+\$AA\$5	0.00219548608061825
26	=W25+5	=W26*\$AA\$4+\$AA\$5	0.00658645824185475
27	=W26+5	=W27*\$AA\$4+\$AA\$5	0.0144902081320804
28	=W27+5	=W28*\$AA\$4+\$AA\$5	0.0276631246157899
29	=W28+5	=W29*\$AA\$4+\$AA\$5	0.0622639852463335
30	=W29+5	=W30*\$AA\$4+\$AA\$5	0.154123122859401
31	=W30+5	=W31*\$AA\$4+\$AA\$5	0.326161412136647
32	=W31+5	=W32*\$AA\$4+\$AA\$5	0.500834284710635
33	=W32+5	=W33*\$AA\$4+\$AA\$5	0.641345393870203
34	=W33+5	=W34*\$AA\$4+\$AA\$5	0.746728725739879
35	=W34+5	=W35*\$AA\$4+\$AA\$5	0.80820233599719
36	=W35+5	=W36*\$AA\$4+\$AA\$5	0.847721085448318
37	=W36+5	=W37*\$AA\$4+\$AA\$5	0.877579696144727
38	=W37+5	=W38*\$AA\$4+\$AA\$5	0.902608237463775
39	=W38+5	=W39*\$AA\$4+\$AA\$5	0.92368490383771
40	=W39+5	=W40*\$AA\$4+\$AA\$5	0.941248792482656
41	=W40+5	=W41*\$AA\$4+\$AA\$5	0.954860806182489
42	=W41+5	=W42*\$AA\$4+\$AA\$5	0.965399139369457
43	=W42+5	=W43*\$AA\$4+\$AA\$5	0.973302889259682
44	=W43+5	=W44*\$AA\$4+\$AA\$5	0.979889347501537
45	=W44+5	=W45*\$AA\$4+\$AA\$5	0.98533415298147
46	=W45+5	=W46*\$AA\$4+\$AA\$5	0.989725125142707
47	=W46+5	=W47*\$AA\$4+\$AA\$5	0.993325722314921
48	=W47+5	=W48*\$AA\$4+\$AA\$5	0.995960305611663
49	=W48+5	=W49*\$AA\$4+\$AA\$5	0.997804513919382
50	=W49+5	=W50*\$AA\$4+\$AA\$5	0.998946166681304
51	=W50+5	=W51*\$AA\$4+\$AA\$5	0.999648722227101
52	=W51+5	=W52*\$AA\$4+\$AA\$5	1

Figure 3.6-1 - EXCEL-generated plot for initial eruptive velocities conditioned on the CDF for conduit diameter.



3.7 Wind Speed CDF

Assumptions used in formulating the wind speed and direction CDFs are discussed in ANL-WIS-MD-000017 Rev00 ICN01 Sections 5.1.1, 5.1.2, and 5.1.3 (CRWMS M&O 2000a).

Quiring (1968) provides wind speed data for the Yucca Mountain region for a seven year period (1957-1964). Data are reported from 5,000-16,000 feet (approximately 1,500-5,000 meters) above sea level for four different months of the year and as a function of wind direction. All wind speed data were averaged (time of year, elevation, and direction) to yield an overall bulk distribution for Yucca Mountain. The data were binned into wind speed intervals (51.44 cm/s = 1 knot intervals) in an EXCEL 97-SR-1 spreadsheet and a CDF was developed based on the number of wind speed occurrences within each bin.

The wind speed data in Quiring (1968), Section 6.0, Tables 6.1 – 6.20 were entered into several different worksheets in a single EXCEL workbook (Wind_Speed_CDF.xls). The data were grouped in the worksheets according to the elevation of the observation, with data for a single elevation entered on a separate worksheet within the workbook. Table 3.7-1 shows the elevations at which wind speed data were available and the relationship between the elevation and worksheet name within the workbook. Table 3.7-2 shows a representative portion of the “5000ft” worksheet in which the wind speed data were entered. The wind speed data provided by Quiring(1968) were in units of knots and were entered into the worksheets in knots. The data values in each worksheet were converted from wind speed in knots to wind speed in cm/s by multiplying by a conversion factor of 51.44. Table 3.7-3 shows the data values in Table 3.7-2 after conversion to cm/s. The column headings in the worksheets correspond to observation month and time of day. The row headings in the worksheets correspond to the wind direction in degrees. The wind directions represent 30 degree increments with the first row representing 15-44 degrees and the last row representing 345-014 degrees. The wind speed data represent an average wind speed for that time of day, in that month, from the given direction and at that elevation for the years 1957 to 1964. Quiring (1968) references 0 degrees to due North with angular wind direction increasing in a clockwise direction. Table 3.7-4 shows the same worksheet in Table 3.7-3 with the “formulas” option in EXCEL enabled to reveal the conversion from knots to cm/s.

The next step in creating the wind speed CDF was to bin the data in the worksheets shown in Table 3.7-1 into 51.44 cm/s (1 knot) intervals. This was accomplished by first copying all of the data points in the worksheets after conversion to cm/s into a single column in a new worksheet within the same workbook (Wind_Speed_CDF.xls). The new worksheet was labeled “CDF”. This new worksheet is shown in Table 3.7-5 and the formulae used in the worksheet are shown in Table 3.7-6. The following paragraphs explain how the “CDF” worksheet was developed.

Each data row (in cm/s) of each wind speed worksheet was consecutively copied (transpose) to the first column (Column A) of the “CDF” worksheet. A total of 2160 data

points in the worksheets (20 date/time combinations times 12 wind directions times 9 elevations) were copied into the first column of the “CDF” worksheet. This column of 2160 data points was then sorted using the EXCEL sort function. The sorted wind speed data were placed in the second column of worksheet “CDF” (Column B). A third column (Column C) was added to this worksheet containing the average wind speed value for each bin. This column was created by assigning a zero (0) to the first cell (row 9) in the column and then adding the bin increment of 51.44448 cm/s to each subsequent cell down the column. Because the bins for 2109.22, 2212.11, and 2315.00 cm/s contained no average wind speed observations, these bins were not included in Column C and the last three entries in this column (Rows 50, 51, and 52) were entered manually.

The number of observations occurring in each bin was counted manually by observing the values in the sorted column of data values (Column B). The number of observations in each bin was manually entered in Column D adjacent to the corresponding wind speed for that bin. The probability of occurrence for each wind speed was then calculated in Column E by dividing the number of observations in Column D by the total number of observations contained in cell D53 (2160). The cumulative distribution function (CDF) was then calculated in Column F by summing the probability values in Column E. The EXCEL-generated plot of this CDF is shown in Figure 3.7-1. This figure is shown as Figure 11 of AMR ANL-WIS-MD-000017 Rev 00 ICN 01 (CRWMS M&O 2000a). The data values from Columns C and F of worksheet “CDF” are also provided in tabular form in Appendix I of the AMR.

Table 3.7-1 - Wind speed data elevation and associated worksheet name in workbook
“Wind_Speed_CDF.xls”

Quiring (1968) data entered into EXCEL workbook Wind_Speed_CDF.xls	
Elevation of Observation (Feet Above Sea Level)	Worksheet Name
5000	“5000ft”
6000	“6000ft”
7000	“7000ft”
8000	“8000ft”
9000	“9000ft”
10000	“10000ft”
12000	“12000ft”
14000	“14000ft”
16000	“16000ft”

Table 3.7-2 Representative portion of EXCEL worksheet containing wind speed data in knots

ROWS	COLUMNS																				
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Wind Speed at 5000 ft amsl in knots																				
2	Wind Dir	Jan 0400	Jan 0700	Jan 1000	Jan 1300	Jan 1600	Apr 0400	Apr 0700	Apr 1000	Apr 1300	Apr 1600	Jul 0400	Jul 0700	Jul 1000	Jul 1300	Jul 1600	Oct 0400	Oct 0700	Oct 1000	Oct 1300	Oct 1600
3	15	10	11	11	9	13	8	8	10	11	18	3	6	0	0	9	11	11	10	10	11
4	45	4	5	4	10	6	6	5	8	7	6	5	0	0	2	0	5	6	6	9	7
5	75	4	4	6	7	3	0	6	4	1	4	0	1	2	4	6	6	0	1	6	0
6	105	8	4	3	2	4	3	19	3	4	5	5	3	1	7	10	5	6	4	7	7
7	135	4	0	5	6	6	9	2	7	9	5	5	4	9	9	6	0	5	5	7	9
8	165	16	13	6	10	10	18	10	13	16	16	12	5	13	16	14	14	9	14	13	11
9	195	16	10	12	11	9	11	10	18	22	21	8	7	11	17	19	15	12	14	15	15
10	225	6	5	8	12	13	9	6	11	10	10	5	4	15	12	14	6	4	4	13	13
11	255	4	5	3	12	10	3	4	2	0	13	4	4	1	0	21	3	4	8	8	18
12	285	4	3	2	15	7	8	9	20	13	11	8	3	0	0	0	4	4	12	5	0
13	315	6	9	10	10	15	11	7	23	16	16	4	9	5	0	0	6	9	9	6	0
14	345	12	12	11	13	3	14	8	11	10	14	12	5	9	0	26	12	10	16	10	16

Table 3.7-3 Representative portion of EXCEL worksheet containing wind speed data in cm/s

ROWS	COLUMNS																				
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
18	Wind Speed at 5000 ft amsl in cm/s																				
19	Wind Dir	Jan 0400	Jan 0700	Jan 1000	Jan 1300	Jan 1600	Apr 0400	Apr 0700	Apr 1000	Apr 1300	Apr 1600	Jul 0400	Jul 0700	Jul 1000	Jul 1300	Jul 1600	Oct 0400	Oct 0700	Oct 1000	Oct 1300	Oct 1600
20	15	514	566	566	463	669	412	412	514	566	926	154	309	0	0	463	566	566	514	514	566
21	45	206	257	206	514	309	309	257	412	360	309	257	0	0	103	0	257	309	309	463	360
22	75	206	206	309	360	154	0	309	206	51	206	0	51	103	206	309	309	0	51	309	0
23	105	412	206	154	103	206	154	977	154	206	257	257	154	51	360	514	257	309	206	360	360
24	135	206	0	257	309	309	463	103	360	463	257	257	206	463	463	309	0	257	257	360	463
25	165	823	669	309	514	514	926	514	669	823	823	617	257	669	823	720	720	463	720	669	566
26	195	823	514	617	566	463	566	514	926	1132	1080	412	360	566	875	977	772	617	720	772	772
27	225	309	257	412	617	669	463	309	566	514	514	257	206	772	617	720	309	206	206	669	669
28	255	206	257	154	617	514	154	206	103	0	669	206	206	51	0	1080	154	206	412	412	926
29	285	206	154	103	772	360	412	463	1029	669	566	412	154	0	0	0	206	206	617	257	0
30	315	309	463	514	514	772	566	360	1183	823	823	206	463	257	0	0	309	463	463	309	0
31	345	617	617	566	669	154	720	412	566	514	720	617	257	463	0	1338	617	514	823	514	823

Table 3.7-4 EXCEL formulae used to generate values shown in Table 3.7-3

ROWS		COLUMNS										
	A	B	C	D	E	F	G	H	I	J	K	
18		Wind Speed at 5000 ft amsl in cm/s										
19	Wind Dir	Jan 0400	Jan 0700	Jan 1000	Jan 1300	Jan 1600	Apr 0400	Apr 0700	Apr 1000	Apr 1300	Apr 1600	
20	15	=B3*51.44	=C3*51.44	=D3*51.44	=E3*51.44	=F3*51.44	=G3*51.44	=H3*51.44	=I3*51.44	=J3*51.44	=K3*51.44	
21	45	=B4*51.44	=C4*51.44	=D4*51.44	=E4*51.44	=F4*51.44	=G4*51.44	=H4*51.44	=I4*51.44	=J4*51.44	=K4*51.44	
22	75	=B5*51.44	=C5*51.44	=D5*51.44	=E5*51.44	=F5*51.44	=G5*51.44	=H5*51.44	=I5*51.44	=J5*51.44	=K5*51.44	
23	105	=B6*51.44	=C6*51.44	=D6*51.44	=E6*51.44	=F6*51.44	=G6*51.44	=H6*51.44	=I6*51.44	=J6*51.44	=K6*51.44	
24	135	=B7*51.44	=C7*51.44	=D7*51.44	=E7*51.44	=F7*51.44	=G7*51.44	=H7*51.44	=I7*51.44	=J7*51.44	=K7*51.44	
25	165	=B8*51.44	=C8*51.44	=D8*51.44	=E8*51.44	=F8*51.44	=G8*51.44	=H8*51.44	=I8*51.44	=J8*51.44	=K8*51.44	
26	195	=B9*51.44	=C9*51.44	=D9*51.44	=E9*51.44	=F9*51.44	=G9*51.44	=H9*51.44	=I9*51.44	=J9*51.44	=K9*51.44	
27	225	=B10*51.44	=C10*51.44	=D10*51.44	=E10*51.44	=F10*51.44	=G10*51.44	=H10*51.44	=I10*51.44	=J10*51.44	=K10*51.44	
28	255	=B11*51.44	=C11*51.44	=D11*51.44	=E11*51.44	=F11*51.44	=G11*51.44	=H11*51.44	=I11*51.44	=J11*51.44	=K11*51.44	
29	285	=B12*51.44	=C12*51.44	=D12*51.44	=E12*51.44	=F12*51.44	=G12*51.44	=H12*51.44	=I12*51.44	=J12*51.44	=K12*51.44	
30	315	=B13*51.44	=C13*51.44	=D13*51.44	=E13*51.44	=F13*51.44	=G13*51.44	=H13*51.44	=I13*51.44	=J13*51.44	=K13*51.44	
31	345	=B14*51.44	=C14*51.44	=D14*51.44	=E14*51.44	=F14*51.44	=G14*51.44	=H14*51.44	=I14*51.44	=J14*51.44	=K14*51.44	

Table 3.7-4 Continued

ROWS	COLUMNS									
	L	M	N	O	P	Q	R	S	T	U
18										
19	Jul 0400	Jul 0700	Jul 1000	Jul 1300	Jul 1600	Oct 0400	Oct 0700	Oct 1000	Oct 1300	Oct 1600
20	=L3*51.44	=M3*51.44	=N3*51.44	=O3*51.44	=P3*51.44	=Q3*51.44	=R3*51.44	=S3*51.44	=T3*51.44	=U3*51.44
21	=L4*51.44	=M4*51.44	=N4*51.44	=O4*51.44	=P4*51.44	=Q4*51.44	=R4*51.44	=S4*51.44	=T4*51.44	=U4*51.44
22	=L5*51.44	=M5*51.44	=N5*51.44	=O5*51.44	=P5*51.44	=Q5*51.44	=R5*51.44	=S5*51.44	=T5*51.44	=U5*51.44
23	=L6*51.44	=M6*51.44	=N6*51.44	=O6*51.44	=P6*51.44	=Q6*51.44	=R6*51.44	=S6*51.44	=T6*51.44	=U6*51.44
24	=L7*51.44	=M7*51.44	=N7*51.44	=O7*51.44	=P7*51.44	=Q7*51.44	=R7*51.44	=S7*51.44	=T7*51.44	=U7*51.44
25	=L8*51.44	=M8*51.44	=N8*51.44	=O8*51.44	=P8*51.44	=Q8*51.44	=R8*51.44	=S8*51.44	=T8*51.44	=U8*51.44
26	=L9*51.44	=M9*51.44	=N9*51.44	=O9*51.44	=P9*51.44	=Q9*51.44	=R9*51.44	=S9*51.44	=T9*51.44	=U9*51.44
27	=L10*51.44	=M10*51.44	=N10*51.44	=O10*51.44	=P10*51.44	=Q10*51.44	=R10*51.44	=S10*51.44	=T10*51.44	=U10*51.44
28	=L11*51.44	=M11*51.44	=N11*51.44	=O11*51.44	=P11*51.44	=Q11*51.44	=R11*51.44	=S11*51.44	=T11*51.44	=U11*51.44
29	=L12*51.44	=M12*51.44	=N12*51.44	=O12*51.44	=P12*51.44	=Q12*51.44	=R12*51.44	=S12*51.44	=T12*51.44	=U12*51.44
30	=L13*51.44	=M13*51.44	=N13*51.44	=O13*51.44	=P13*51.44	=Q13*51.44	=R13*51.44	=S13*51.44	=T13*51.44	=U13*51.44
31	=L14*51.44	=M14*51.44	=N14*51.44	=O14*51.44	=P14*51.44	=Q14*51.44	=R14*51.44	=S14*51.44	=T14*51.44	=U14*51.44

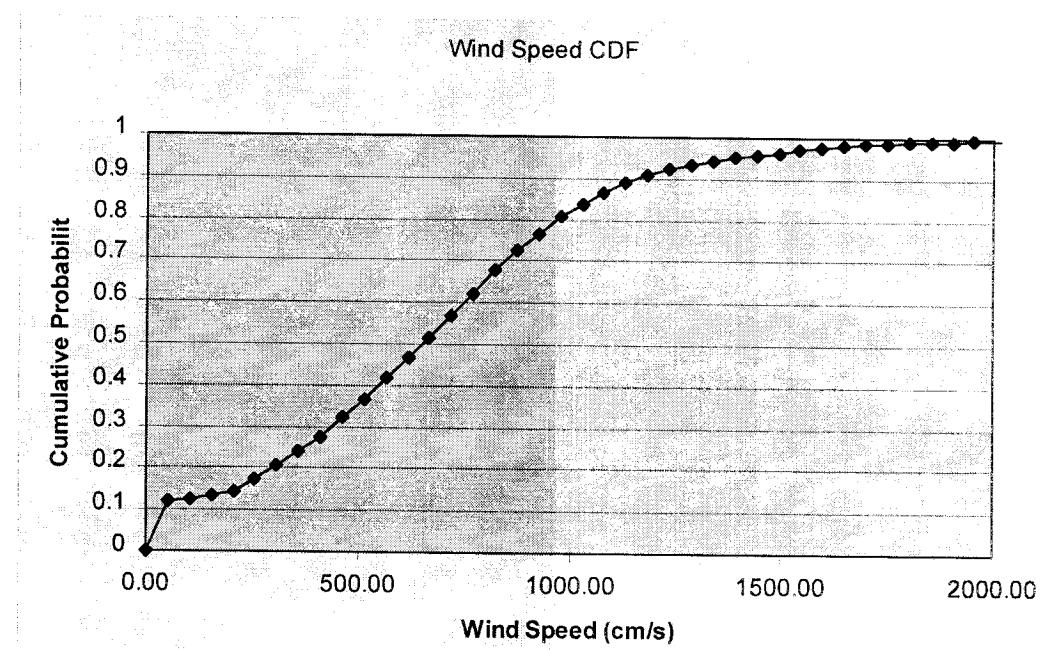
Table 3.7-5 EXCEL worksheet used to develop wind speed CDF

ROWS	COLUMNS					
	A	B	C	D	E	F
8	Quiring (1968) Data (cm/s)	Column A Sorted	51.44448 cm/s Bins	# occurrences	Probability	CDF
9	514	0	0.00	257	0.1190	0
10	566	0	51.44	9	0.0042	0.1190
11	566	0	102.89	21	0.0097	0.1231
12	463	0	154.33	26	0.0120	0.1329
13	669	0	205.78	58	0.0269	0.1449
14	412	0	257.22	73	0.0338	0.1718
15	412	0	308.67	75	0.0347	0.2056
16	514	0	360.11	75	0.0347	0.2403
17	566	0	411.56	99	0.0458	0.2750
18	926	0	463.00	95	0.0440	0.3208
19	154	0	514.44	118	0.0546	0.3648
20	309	0	565.89	99	0.0458	0.4194
21	0	0	617.33	109	0.0505	0.4653
22	0	0	668.78	114	0.0528	0.5157
23	463	0	720.22	113	0.0523	0.5685
24	566	0	771.67	126	0.0583	0.6208
25	566	0	823.11	99	0.0458	0.6792
26	514	0	874.56	87	0.0403	0.7250
27	514	0	926.00	88	0.0407	0.7653
28	566	0	977.45	63	0.0292	0.8060
29	823	0	1028.89	65	0.0301	0.8352
30	720	0	1080.33	48	0.0222	0.8653
31	617	0	1131.78	48	0.0222	0.8875
32	566	0	1183.22	30	0.0139	0.9097
33	566	0	1234.67	19	0.0088	0.9236
34	566	0	1286.11	20	0.0093	0.9324
35	463	0	1337.56	19	0.0088	0.9417
36	514	0	1389.00	16	0.0074	0.9505
37	463	0	1440.45	12	0.0056	0.9579
38	772	0	1491.89	14	0.0065	0.9634
39	566	0	1543.33	12	0.0056	0.9699
40	514	0	1594.78	9	0.0042	0.9755
41	0	0	1646.22	8	0.0037	0.9796
42	0	0	1697.67	6	0.0028	0.9833
43	617	0	1749.11	6	0.0028	0.9861
44	823	0	1800.56	4	0.0019	0.9889
45	720	0	1852.00	3	0.0014	0.9907
46	669	0	1903.45	3	0.0014	0.9921
47	514	0	1954.89	3	0.0014	0.9935
48	669	0	2006.33	4	0.0019	0.9949
49	1029	0	2057.78	4	0.0019	0.9968
50	823	0	2160.67	1	0.0005	0.9986
51	669	0	2263.56	1	0.0005	0.9991
52	669	0	2366.45	1	0.0005	1.0000
53	566	0		2160	1.0000	
54	875	0		Total Obs.	Total Prob.	
55	772	0				
56	463	0				
.	.	.				
(2,107 rows not shown)						
2164	772	2058				
2165	1338	2058				
2166	1029	2161				
2167	823	2264				
2168	772	2366				

Table 3.7-6 EXCEL formulae used to generate values shown in Table 3.7-5

	COLUMNS					
ROWS	A	B	C	D	E	F
8	Quiring (1968) Data (cm/s)	Column A Sorted	51.44448 cm/s Bins	No. of occurrences	Probability	CDF
9	514.4448	0	0	257	=D9/D\$53	0
10	565.88928	0	=C9+51.44448	9	=D10/D\$53	=F9+E9
11	565.88928	0	=C10+51.44448	21	=D11/D\$53	=F10+E10
12	463.00032	0	=C11+51.44448	26	=D12/D\$53	=F11+E11
13	668.77824	0	=C12+51.44448	58	=D13/D\$53	=F12+E12
14	411.55584	0	=C13+51.44448	73	=D14/D\$53	=F13+E13
15	411.55584	0	=C14+51.44448	75	=D15/D\$53	=F14+E14
16	514.4448	0	=C15+51.44448	75	=D16/D\$53	=F15+E15
17	565.88928	0	=C16+51.44448	99	=D17/D\$53	=F16+E16
18	926.00064	0	=C17+51.44448	95	=D18/D\$53	=F17+E17
19	154.33344	0	=C18+51.44448	118	=D19/D\$53	=F18+E18
20	308.66688	0	=C19+51.44448	99	=D20/D\$53	=F19+E19
21	0	0	=C20+51.44448	109	=D21/D\$53	=F20+E20
22	0	0	=C21+51.44448	114	=D22/D\$53	=F21+E21
23	463.00032	0	=C22+51.44448	113	=D23/D\$53	=F22+E22
24	565.88928	0	=C23+51.44448	126	=D24/D\$53	=F23+E23
25	565.88928	0	=C24+51.44448	99	=D25/D\$53	=F24+E24
26	514.4448	0	=C25+51.44448	87	=D26/D\$53	=F25+E25
27	514.4448	0	=C26+51.44448	88	=D27/D\$53	=F26+E26
28	565.88928	0	=C27+51.44448	63	=D28/D\$53	=F27+E27
29	823.11168	0	=C28+51.44448	65	=D29/D\$53	=F28+E28
30	720.22272	0	=C29+51.44448	48	=D30/D\$53	=F29+E29
31	617.33376	0	=C30+51.44448	48	=D31/D\$53	=F30+E30
32	565.88928	0	=C31+51.44448	30	=D32/D\$53	=F31+E31
33	565.88928	0	=C32+51.44448	19	=D33/D\$53	=F32+E32
34	565.88928	0	=C33+51.44448	20	=D34/D\$53	=F33+E33
35	463.00032	0	=C34+51.44448	19	=D35/D\$53	=F34+E34
36	514.4448	0	=C35+51.44448	16	=D36/D\$53	=F35+E35
37	463.00032	0	=C36+51.44448	12	=D37/D\$53	=F36+E36
38	771.6672	0	=C37+51.44448	14	=D38/D\$53	=F37+E37
39	565.88928	0	=C38+51.44448	12	=D39/D\$53	=F38+E38
40	514.4448	0	=C39+51.44448	9	=D40/D\$53	=F39+E39
41	0	0	=C40+51.44448	8	=D41/D\$53	=F40+E40
42	0	0	=C41+51.44448	6	=D42/D\$53	=F41+E41
43	617.33376	0	=C42+51.44448	6	=D43/D\$53	=F42+E42
44	823.11168	0	=C43+51.44448	4	=D44/D\$53	=F43+E43
45	720.22272	0	=C44+51.44448	3	=D45/D\$53	=F44+E44
46	668.77824	0	=C45+51.44448	3	=D46/D\$53	=F45+E45
47	514.4448	0	=C46+51.44448	3	=D47/D\$53	=F46+E46
48	668.77824	0	=C47+51.44448	4	=D48/D\$53	=F47+E47
49	1028.8896	0	=C48+51.44448	4	=D49/D\$53	=F48+E48
50	823.11168	0	2160.67	1	=D50/D\$53	=F49+E49
51	668.77824	0	2263.56	1	=D51/D\$53	=F50+E50
52	668.77824	0	2366.45	1	=D52/D\$53	1
53	565.88928	0		=SUM(D9:D52)	=SUM(E9:E52)	
54	874.55616	0		Total Obs.	Total Prob.	
55	771.6672	0				
56	463.00032	0				
.	.	.				
(2,107 rows not shown)						
.						
2164	771.6672	2057.7792				
2165	1337.55648	2057.7792				
2166	1028.8896	2160.66816				
2167	823.11168	2263.55712				
2168	771.6672	2366.44608				

Figure 3.7-1 EXCEL-generated plot for wind speed CDF



3.8 Wind Direction PDF

Assumptions used in formulating the wind speed and direction CDFs are discussed in ANL-WIS-MD-000017 Rev00 ICN01 Sections 5.1.1, 5.1.2, and 5.1.3 (CRWMS M&O 2000a).

Quiring (1968) provides wind direction frequency data for the Yucca Mountain region for a seven year period (1957-1964). The wind direction frequency data ranged from 5,000-16,000 feet (approximately 1,500 – 5,000 meters) above sea level and was reported over four different months of the year and as a function of wind speed. All wind direction data were averaged together (time of year, elevation, and wind speed) to yield an overall bulk distribution for Yucca Mountain. The data were grouped into 30 degree intervals in a spreadsheet and a PDF was developed based on the percent frequency of occurrence of wind direction within each group.

The wind direction percent frequency data from Quiring (1968), Section 6.0, Tables 6.1 – 6.20 were entered into a single EXCEL worksheet (Wind_Direction_PDF.xls). Table 3.8-1 shows a typical portion of the worksheet containing wind direction frequency data for January at 0400 PST and 0700 PST. Data for a total of twenty (20) different month/time combinations were entered into the worksheet. Data for 0400, 0700, 1000, 1300, and 1600 PST and the months of January, April, July, and October were entered. (Note that data for only January at 0400 and 0700 are shown in Table 3.8-1 for the purpose of illustrating the worksheet calculations.) These 20 month/time combinations were taken from the 20 Tables provided by Quiring (1968). The data in each table represent the percent frequency the wind was blowing from the direction in the first column in the tables averaged over all observations for that month and time of day. The wind direction shown in the first column in the table actually represents the mid-point of a 30 degree range of wind directions. For example, the first row of the tables is for a range of wind directions of 15 to 44 degrees and the last row of the tables is for a range of wind directions of 345 – 14 degrees. Quiring (1968) references 0 degrees to North with angular wind direction increasing in a clockwise direction.

To construct the wind direction PDF, the data in the worksheet was first averaged by Month. Table 3.8-2 shows a portion of the worksheet which contains the wind direction averages for the month of January. This table was created by simply adding the corresponding values from the January data tables for the five times of day and dividing by five. Table 3.8-3 shows the same table with the EXCEL formulae visible. The next step was to average over the entire year. Table 3.8-4 shows the portion of the EXCEL worksheet where the averaging calculation was done. The averages for each of the four months were averaged together in the table shown in Table 3.8-4. An additional column was then added to this table (Heading “AVG”, Column M) in which the data were averaged over all elevations. Table 3.8-5 shows the same table with the EXCEL formulae used to calculate the averages.

Because the ASHPLUME code assumes 90 degrees represents North and -90 degrees represents South, an additional column (Column A) was added to the worksheet (Table

3.8-4) containing the angular directions in the ASHPLUME reference system. Table 3.8-6 shows the appropriate columns from the worksheet with wind direction in ASHPLUME coordinates, Quiring (1968) coordinates, and the average wind frequency in percent. Figure 3.8-1 was created in the EXCEL worksheet and shows the wind rose frequency of occurrences for the wind “from” direction in the ASHPLUME coordinate system. This is a plot of data contained in columns A and M in Table 3.8-6. This plot is provided as Figure 12 in the AMR ANL-WIS-MD-000017 Rev00 ICN01 (CRWMS M&O 2000a).

Because the ASHPLUME code requires wind direction to be entered as the direction the wind is blowing towards, another table was created in the worksheet to provide the wind speed averages in a “towards” format. This portion of the worksheet is shown in Table 3.8-7. Table 3.8-8 shows the table with the EXCEL formulae revealed. The first two columns in this table were entered manually. Each entry in the third column of the table was taken from column M and the appropriate row of Table 3.8-6 and divided by 100 to convert from frequency percent to the frequency fraction needed for the wind speed PDF. Four points in Table 3.8-7 differ from those given in Appendix I of the AMR ANL-WIS-MD-000017 Rev00 ICN01 (CRWMS M&O 2000a). The four points listed incorrectly in the AMR are indicated in Table 3.8-7. This error in the AMR table will have no impact on TSPA-SR calculations because this wind speed data is not used in the TSPA-SR analysis. For the TSPA-SR analysis, the wind direction is assumed to be blowing towards the South in all model calculations.

Table 3.8-1 Representative portion of EXCEL worksheet containing Quiring (1968) wind direction data in percent frequency (From Tables 6.1 and 6.2 in Quiring (1968))

ROWS	COLUMNS										
	C	D	E	F	G	H	I	J	K	L	
1	January										0400 PST
2	Wind Direction +/- 15°										
3	Height Above Seal Level (Ft)										
4		5000	6000	7000	8000	9000	10000	12000	14000	16000	
5	30	17	18	14	10	8	5	4	5	3	
6	60	3	5	8	8	7	8	7	3	4	
7	90	2	3	3	3	2	1	0	3	5	
8	120	1	3	1	2	2	1	2	3	3	
9	150	4	3	2	1	2	1	1	0	0	
10	180	2	9	7	5	3	3	1	1	0	
11	210	9	12	18	22	16	13	10	7	8	
12	240	7	3	7	7	10	14	10	14	12	
13	270	3	4	3	2	7	8	13	13	15	
14	300	3	6	9	9	10	11	21	21	24	
15	330	12	9	5	15	16	21	16	21	17	
16	360	36	26	23	17	16	13	14	9	10	
17	Calm	2	1	1	1	1	1	1	1	1	
18		101	102	101	102	100	100	100	101	102	
19											
20											
21	Wind Direction +/- 15°	0700 PST									
22		Height Above Seal Level (Ft)									
23		5000	6000	7000	8000	9000	10000	12000	14000	16000	
24	30	14	28	21	15	12	7	8	3	3	
25	60	2	4	10	10	8	7	9	6	10	
26	90	1	2	1	3	2	3	0	4	2	
27	120	1	2	4	2	2	3	3	4	2	
28	150	0	2	0	0	0	0	0	0	0	
29	180	5	4	6	6	3	3	3	1	1	
30	210	9	16	14	14	13	7	3	3	5	
31	240	4	3	6	6	10	9	10	10	7	
32	270	2	2	3	4	3	7	10	11	14	
33	300	6	6	5	6	11	15	19	21	19	
34	330	10	6	9	15	17	17	18	20	21	
35	360	44	26	21	19	19	22	19	18	16	
36	Calm	2	0	0	0	0	0	0	0	0	
37		100	101	100	100	100	100	102	101	100	

Table 3.8-2 EXCEL values for average wind direction for the month of January

ROWS	COLUMNS										
	C	D	E	F	G	H	I	J	K	L	
	January - Avg Times throughout the Day										
	Wind Direction +/- 15°										
	Height Above Sea Level (Ft)										
99		5000	6000	7000	8000	9000	10000	12000	14000	16000	
100	0	28.8	20.8	20	19.6	19.6	16.8	18.6	15	14.8	
101	30	17.6	22.4	16.4	12.6	11	10	7.2	5.8	4.2	
102	60	4.4	6.8	10	9.8	8.6	7.8	7	5.6	6.6	
103	90	2	2	1.6	2.6	2.2	2.4	2.8	4.4	4.8	
104	120	2.2	1.6	1.8	1.4	1.4	2	2.2	2.6	2.4	
105	150	2.8	2	1.2	1.2	1	0.6	0.6	0.8	0.6	
106	180	9.2	7.8	6.8	5.6	4	2.8	1.2	0.8	0.8	
107	210	12.8	13.8	14.8	13.8	12	8	4.6	4	4.4	
108	240	5	5	5.6	7.4	9.8	10.4	10.4	9.8	8.4	
109	270	2.2	4	3.8	4.2	4.6	8.2	12	12.6	14.4	
110	300	3.4	5	8	7.8	9.6	12.4	18	19.2	21.4	
111	330	10.2	9.8	11.4	14.8	16	17.8	16	20.2	18	
112	Calm	1.4	0.4	0.2	0.2	0.2	0.4	0.2	0.2	0.2	
113		102	101.4	101.6	101	100	99.6	100.8	101	101	

Table 3.8-3 EXCEL formulae used to generate values shown in Table 3.8-2

ROW S	COLUMNS				
	C	D	E	F	G
January - Avg Times throughout the Day					
Wind Direction +/- 15°					
99	Height Above Seal Level (Ft)				
	5000	6000	7000	8000	
100	0	=SUM(D16,D35,D54,D73,D92)/5	=SUM(E16,E35,E54,E73,E92)/5	=SUM(F16,F35,F54,F73,F92)/5	=SUM(G16,G35,G54,G73,G92)/5
101	30	=SUM(D5,D24,D43,D62,D81)/5	=SUM(E5,E24,E43,E62,E81)/5	=SUM(F5,F24,F43,F62,F81)/5	=SUM(G5,G24,G43,G62,G81)/5
102	60	=SUM(D6,D25,D44,D63,D82)/5	=SUM(E6,E25,E44,E63,E82)/5	=SUM(F6,F25,F44,F63,F82)/5	=SUM(G6,G25,G44,G63,G82)/5
103	90	=SUM(D7,D26,D45,D64,D83)/5	=SUM(E7,E26,E45,E64,E83)/5	=SUM(F7,F26,F45,F64,F83)/5	=SUM(G7,G26,G45,G64,G83)/5
104	120	=SUM(D8,D27,D46,D65,D84)/5	=SUM(E8,E27,E46,E65,E84)/5	=SUM(F8,F27,F46,F65,F84)/5	=SUM(G8,G27,G46,G65,G84)/5
105	150	=SUM(D9,D28,D47,D66,D85)/5	=SUM(E9,E28,E47,E66,E85)/5	=SUM(F9,F28,F47,F66,F85)/5	=SUM(G9,G28,G47,G66,G85)/5
106	180	=SUM(D10,D29,D48,D67,D86)/5	=SUM(E10,E29,E48,E67,E86)/5	=SUM(F10,F29,F48,F67,F86)/5	=SUM(G10,G29,G48,G67,G86)/5
107	210	=SUM(D11,D30,D49,D68,D87)/5	=SUM(E11,E30,E49,E68,E87)/5	=SUM(F11,F30,F49,F68,F87)/5	=SUM(G11,G30,G49,G68,G87)/5
108	240	=SUM(D12,D31,D50,D69,D88)/5	=SUM(E12,E31,E50,E69,E88)/5	=SUM(F12,F31,F50,F69,F88)/5	=SUM(G12,G31,G50,G69,G88)/5
109	270	=SUM(D13,D32,D51,D70,D89)/5	=SUM(E13,E32,E51,E70,E89)/5	=SUM(F13,F32,F51,F70,F89)/5	=SUM(G13,G32,G51,G70,G89)/5
110	300	=SUM(D14,D33,D52,D71,D90)/5	=SUM(E14,E33,E52,E71,E90)/5	=SUM(F14,F33,F52,F71,F90)/5	=SUM(G14,G33,G52,G71,G90)/5
111	330	=SUM(D15,D34,D53,D72,D91)/5	=SUM(E15,E34,E53,E72,E91)/5	=SUM(F15,F34,F53,F72,F91)/5	=SUM(G15,G34,G53,G72,G91)/5
112	Calm	=SUM(D17,D36,D55,D74,D93)/5	=SUM(E17,E36,E55,E74,E93)/5	=SUM(F17,F36,F55,F74,F93)/5	=SUM(G17,G36,G55,G74,G93)/5
113		=SUM(D100:D112)	=SUM(E100:E112)	=SUM(F100:F112)	=SUM(G100:G112)

Table 3.8-3 Continued

ROWS	COLUMNS				
	H	I	J	K	L
Height Above Seal Level (Ft)					
99	9000	10000	12000	14000	16000
100	=SUM(H16,H35,H54,H73,H92)/5	=SUM(I16,I35,I54,I73,I92)/5	=SUM(J16,J35,J54,J73,J92)/5	=SUM(K16,K35,K54,K73,K92)/5	=SUM(L16,L35,L54,L73,L92)/5
101	=SUM(H5,H24,H43,H62,H81)/5	=SUM(I5,I24,I43,I62,I81)/5	=SUM(J5,J24,J43,J62,J81)/5	=SUM(K5,K24,K43,K62,K81)/5	=SUM(L5,L24,L43,L62,L81)/5
102	=SUM(H6,H25,H44,H63,H82)/5	=SUM(I6,I25,I44,I63,I82)/5	=SUM(J6,J25,J44,J63,J82)/5	=SUM(K6,K25,K44,K63,K82)/5	=SUM(L6,L25,L44,L63,L82)/5
103	=SUM(H7,H26,H45,H64,H83)/5	=SUM(I7,I26,I45,I64,I83)/5	=SUM(J7,J26,J45,J64,J83)/5	=SUM(K7,K26,K45,K64,K83)/5	=SUM(L7,L26,L45,L64,L83)/5
104	=SUM(H8,H27,H46,H65,H84)/5	=SUM(I8,I27,I46,I65,I84)/5	=SUM(J8,J27,J46,J65,J84)/5	=SUM(K8,K27,K46,K65,K84)/5	=SUM(L8,L27,L46,L65,L84)/5
105	=SUM(H9,H28,H47,H66,H85)/5	=SUM(I9,I28,I47,I66,I85)/5	=SUM(J9,J28,J47,J66,J85)/5	=SUM(K9,K28,K47,K66,K85)/5	=SUM(L9,L28,L47,L66,L85)/5
106	=SUM(H10,H29,H48,H67,H86)/5	=SUM(I10,I29,I48,I67,I86)/5	=SUM(J10,J29,J48,J67,J86)/5	=SUM(K10,K29,K48,K67,K86)/5	=SUM(L10,L29,L48,L67,L86)/5
107	=SUM(H11,H30,H49,H68,H87)/5	=SUM(I11,I30,I49,I68,I87)/5	=SUM(J11,J30,J49,J68,J87)/5	=SUM(K11,K30,K49,K68,K87)/5	=SUM(L11,L30,L49,L68,L87)/5
108	=SUM(H12,H31,H50,H69,H88)/5	=SUM(I12,I31,I50,I69,I88)/5	=SUM(J12,J31,J50,J69,J88)/5	=SUM(K12,K31,K50,K69,K88)/5	=SUM(L12,L31,L50,L69,L88)/5
109	=SUM(H13,H32,H51,H70,H89)/5	=SUM(I13,I32,I51,I70,I89)/5	=SUM(J13,J32,J51,J70,J89)/5	=SUM(K13,K32,K51,K70,K89)/5	=SUM(L13,L32,L51,L70,L89)/5
110	=SUM(H14,H33,H52,H71,H90)/5	=SUM(I14,I33,I52,I71,I90)/5	=SUM(J14,J33,J52,J71,J90)/5	=SUM(K14,K33,K52,K71,K90)/5	=SUM(L14,L33,L52,L71,L90)/5
111	=SUM(H15,H34,H53,H72,H91)/5	=SUM(I15,I34,I53,I72,I91)/5	=SUM(J15,J34,J53,J72,J91)/5	=SUM(K15,K34,K53,K72,K91)/5	=SUM(L15,L34,L53,L72,L91)/5
112	=SUM(H17,H36,H55,H74,H93)/5	=SUM(I17,I36,I55,I74,I93)/5	=SUM(J17,J36,J55,J74,J93)/5	=SUM(K17,K36,K55,K74,K93)/5	=SUM(L17,L36,L55,L74,L93)/5
113	=SUM(H100:H112)	=SUM(I100:I112)	=SUM(J100:J112)	=SUM(K100:K112)	=SUM(L100:L112)

Table 3.8-4 EXCEL values for wind direction averaged over the entire year

ROWS	COLUMNS											
	C	D	E	F	G	H	I	J	K	L	M	
	Average Over the Entire Year											
	Wind Direction (+/- 15 degreed)											
138		5000	6000	7000	8000	9000	10000	12000	14000	16000	Avg	
139	0	16.15	12	11.1	11.35	11.15	10.35	9.9	8.55	7.65	10.91	
140	30	11.55	13.45	11.6	9.25	8	7.2	5.15	5.15	4.6	8.439	
141	60	4.15	5.75	6.05	5.55	4.95	4.35	4.15	3.55	3.8	4.7	
142	90	1.8	1.7	1.8	2.4	1.8	2.05	3.15	3.2	2.45	2.261	
143	120	3.25	2.45	2.4	2.3	2.45	2.05	3.15	3.15	3.15	2.706	
144	150	5.75	3.8	3.3	3.1	3.5	4.05	3.35	3.5	3	3.706	
145	180	16.85	16.7	15.45	14.4	13.35	12.15	9.85	8.4	6.2	12.59	
146	210	21.15	26.1	26.7	26.9	25.25	22.5	18.5	15.2	14.15	21.83	
157	240	5.7	5.8	7.2	7.45	9.15	10.55	12.7	15.65	17.2	10.16	
148	270	2.65	3.2	3.4	4.05	4.55	6.15	8.4	10.85	13	6.25	
149	300	3.6	3.9	4.6	4.85	6.45	7.45	10.75	10.85	13	7.272	
150	330	6.8	5.2	6.6	8.4	9.4	10.7	10.85	12.6	12.4	9.217	
151	Calm	1.4	0.3	0.3	0.1	0.05	0.35	0.1	0.2	0.15	0.328	
152		100.8	100.4	100.5	100.1	100.1	99.9	100	100.9	100.8	100.4	

Table 3.8-5 EXCEL Formulae used to generate the values shown in Table 3.8-4

ROWS	COLUMNS					
	C	D	E	F	G	
	Average Over the Entire Year					
	Wind Direction (+/- 15 Degrees)					
138		5000	6000	7000	8000	
139	0	=SUM(D100,O100,Z100,AK100)/4	=SUM(E100,P100,AA100,AL100)/4	=SUM(F100,Q100,AB100,AM100)/4	=SUM(G100,R100,AC100,AN100)/4	
140	30	=SUM(D101,O101,Z101,AK101)/4	=SUM(E101,P101,AA101,AL101)/4	=SUM(F101,Q101,AB101,AM101)/4	=SUM(G101,R101,AC101,AN101)/4	
141	60	=SUM(D102,O102,Z102,AK102)/4	=SUM(E102,P102,AA102,AL102)/4	=SUM(F102,Q102,AB102,AM102)/4	=SUM(G102,R102,AC102,AN102)/4	
142	90	=SUM(D103,O103,Z103,AK103)/4	=SUM(E103,P103,AA103,AL103)/4	=SUM(F103,Q103,AB103,AM103)/4	=SUM(G103,R103,AC103,AN103)/4	
143	120	=SUM(D104,O104,Z104,AK104)/4	=SUM(E104,P104,AA104,AL104)/4	=SUM(F104,Q104,AB104,AM104)/4	=SUM(G104,R104,AC104,AN104)/4	
144	150	=SUM(D105,O105,Z105,AK105)/4	=SUM(E105,P105,AA105,AL105)/4	=SUM(F105,Q105,AB105,AM105)/4	=SUM(G105,R105,AC105,AN105)/4	
145	180	=SUM(D106,O106,Z106,AK106)/4	=SUM(E106,P106,AA106,AL106)/4	=SUM(F106,Q106,AB106,AM106)/4	=SUM(G106,R106,AC106,AN106)/4	
146	210	=SUM(D107,O107,Z107,AK107)/4	=SUM(E107,P107,AA107,AL107)/4	=SUM(F107,Q107,AB107,AM107)/4	=SUM(G107,R107,AC107,AN107)/4	
147	240	=SUM(D108,O108,Z108,AK108)/4	=SUM(E108,P108,AA108,AL108)/4	=SUM(F108,Q108,AB108,AM108)/4	=SUM(G108,R108,AC108,AN108)/4	
148	270	=SUM(D109,O109,Z109,AK109)/4	=SUM(E109,P109,AA109,AL109)/4	=SUM(F109,Q109,AB109,AM109)/4	=SUM(G109,R109,AC109,AN109)/4	
149	300	=SUM(D110,O110,Z110,AK110)/4	=SUM(E110,P110,AA110,AL110)/4	=SUM(F110,Q110,AB110,AM110)/4	=SUM(G110,R110,AC110,AN110)/4	
150	330	=SUM(D111,O111,Z111,AK111)/4	=SUM(E111,P111,AA111,AL111)/4	=SUM(F111,Q111,AB111,AM111)/4	=SUM(G111,R111,AC111,AN111)/4	
151	Calm	=SUM(D112,O112,Z112,AK112)/4	=SUM(E112,P112,AA112,AL112)/4	=SUM(F112,Q112,AB112,AM112)/4	=SUM(G112,R112,AC112,AN112)/4	
152		=SUM(D139:D151)	=SUM(E139:E151)	=SUM(F139:F151)	=SUM(G139:G151)	

Table 3.8-5 Continued

ROWS	COLUMNS		
	H	I	J
Height Above Sea Level (ft)			
138	9000	10000	12000
139	=SUM(H100,S100,AD100,AO100)/4	=SUM(I100,T100,AE100,AP100)/4	=SUM(J100,U100,AF100,AQ100)/4
140	=SUM(H101,S101,AD101,AO101)/4	=SUM(I101,T101,AE101,AP101)/4	=SUM(J101,U101,AF101,AQ101)/4
141	=SUM(H102,S102,AD102,AO102)/4	=SUM(I102,T102,AE102,AP102)/4	=SUM(J102,U102,AF102,AQ102)/4
142	=SUM(H103,S103,AD103,AO103)/4	=SUM(I103,T103,AE103,AP103)/4	=SUM(J103,U103,AF103,AQ103)/4
143	=SUM(H104,S104,AD104,AO104)/4	=SUM(I104,T104,AE104,AP104)/4	=SUM(J104,U104,AF104,AQ104)/4
144	=SUM(H105,S105,AD105,AO105)/4	=SUM(I105,T105,AE105,AP105)/4	=SUM(J105,U105,AF105,AQ105)/4
145	=SUM(H106,S106,AD106,AO106)/4	=SUM(I106,T106,AE106,AP106)/4	=SUM(J106,U106,AF106,AQ106)/4
146	=SUM(H107,S107,AD107,AO107)/4	=SUM(I107,T107,AE107,AP107)/4	=SUM(J107,U107,AF107,AQ107)/4
147	=SUM(H108,S108,AD108,AO108)/4	=SUM(I108,T108,AE108,AP108)/4	=SUM(J108,U108,AF108,AQ108)/4
148	=SUM(H109,S109,AD109,AO109)/4	=SUM(I109,T109,AE109,AP109)/4	=SUM(J109,U109,AF109,AQ109)/4
149	=SUM(H110,S110,AD110,AO110)/4	=SUM(I110,T110,AE110,AP110)/4	=SUM(J110,U110,AF110,AQ110)/4
150	=SUM(H111,S111,AD111,AO111)/4	=SUM(I111,T111,AE111,AP111)/4	=SUM(J111,U111,AF111,AQ111)/4
151	=SUM(H112,S112,AD112,AO112)/4	=SUM(I112,T112,AE112,AP112)/4	=SUM(J112,U112,AF112,AQ112)/4
152	=SUM(H139:H151)	=SUM(I139:I151)	=SUM(J139:J151)

Table 3.8-5 Continued

ROWS	COLUMNS		
	K	L	M
Height Above Sea Level (ft)			
138	14000	16000	
139	=SUM(K100,V100,AG100,AR100)/4	=SUM(L100,W100,AH100,AS100)/4	=SUM(D139:L139)/9
140	=SUM(K101,V101,AG101,AR101)/4	=SUM(L101,W101,AH101,AS101)/4	=SUM(D140:L140)/9
141	=SUM(K102,V102,AG102,AR102)/4	=SUM(L102,W102,AH102,AS102)/4	=SUM(D141:L141)/9
142	=SUM(K103,V103,AG103,AR103)/4	=SUM(L103,W103,AH103,AS103)/4	=SUM(D142:L142)/9
143	=SUM(K104,V104,AG104,AR104)/4	=SUM(L104,W104,AH104,AS104)/4	=SUM(D143:L143)/9
144	=SUM(K105,V105,AG105,AR105)/4	=SUM(L105,W105,AH105,AS105)/4	=SUM(D144:L144)/9
145	=SUM(K106,V106,AG106,AR106)/4	=SUM(L106,W106,AH106,AS106)/4	=SUM(D145:L145)/9
146	=SUM(K107,V107,AG107,AR107)/4	=SUM(L107,W107,AH107,AS107)/4	=SUM(D146:L146)/9
147	=SUM(K108,V108,AG108,AR108)/4	=SUM(L108,W108,AH108,AS108)/4	=SUM(D147:L147)/9
148	=SUM(K109,V109,AG109,AR109)/4	=SUM(L109,W109,AH109,AS109)/4	=SUM(D148:L148)/9
149	=SUM(K110,V110,AG110,AR110)/4	=SUM(L110,W110,AH110,AS110)/4	=SUM(D149:L149)/9
150	=SUM(K111,V111,AG111,AR111)/4	=SUM(L111,W111,AH111,AS111)/4	=SUM(D150:L150)/9
151	=SUM(K112,V112,AG112,AR112)/4	=SUM(L112,W112,AH112,AS112)/4	=SUM(D151:L151)/9
152	=SUM(K139,K151)	=SUM(L139:L151)	=SUM(M139:M151)

Table 3.8-6 EXCEL values for wind direction blowing from in both ASHPLUME and Quiring (1968) coordinates

ROWS	COLUMNS		
	A	C	M
Wind Blowing From			
	ASHPLUME Coordinates	Quiring (1968) Coordinates	Average Wind Frequency (percent)
139	90 (North)	0	10.91
140	60	30	8.439
141	30	60	4.7
142	0 (East)	90	2.261
143	-30	120	2.706
144	-60	150	3.706
145	-90 (South)	180	12.59
146	-120	210	21.83
147	-150	240	10.16
148	180 (West)	270	6.25
149	150	300	7.272
150	120	330	9.217

Table 3.8-7 EXCEL values for wind direction PDF

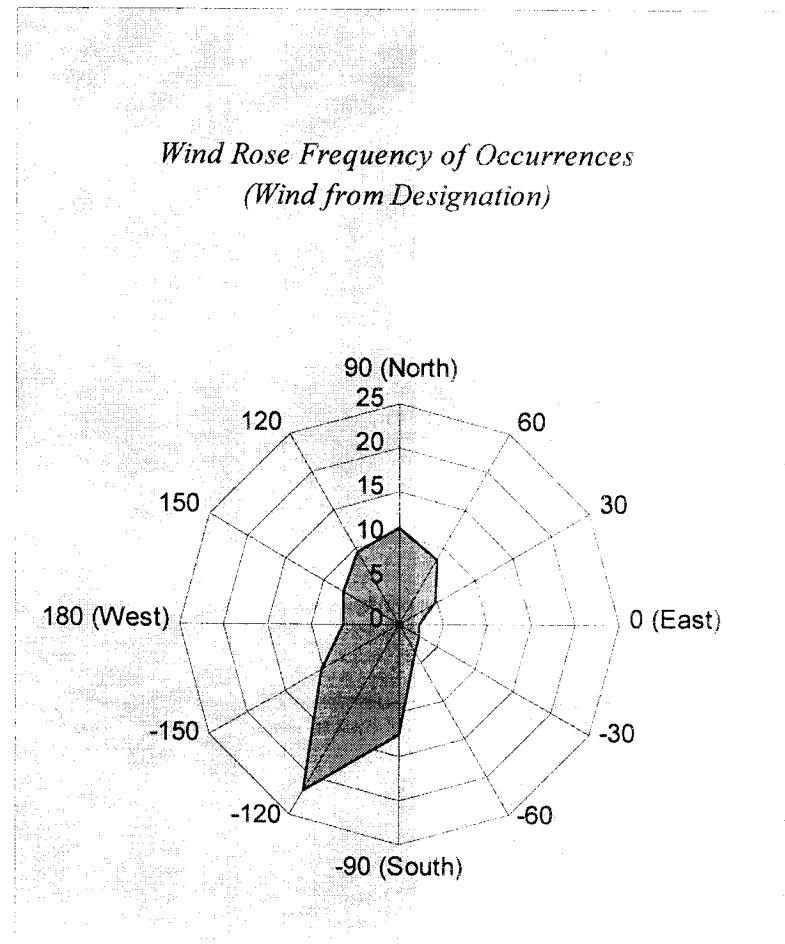
ROWS	COLUMNS		
	A	B	C
154	Wind Direction (Blowing Towards)	Wind Direction (ASHPLUME Degrees)	PDF
155	West-South	-150	0.047 *
156	South-West	-120	0.084 *
157	South	-90	0.109
158	South-East	-60	0.092 *
159	East-South	-30	0.073 *
160	East	0	0.063
161	East-North	30	0.102
162	North-East	60	0.218
163	North	90	0.126
164	North-West	120	0.037
165	West-North	150	0.027
166	West	180	0.023

Values marked with (*) differ from those given in ANL-WIS-MD-000017 Rev. 00 ICN 01.

Table 3.8-8 EXCEL formulae used to generate the values shown in Table 3.8-7

ROWS	COLUMNS		
	A	B	C
154	Wind Direction (Blowing Towards)	Wind Direction (ASHPLUME Degrees)	PDF
155	West-South	-150	=M141/100
156	South-West	-120	=M140/100
157	South	-90	=M139/100
158	South-East	-60	=M150/100
159	East-South	-30	=M149/100
160	East	0	=M148/100
161	East-North	30	=M147/100
162	North-East	60	=M146/100
163	North	90	=M145/100
164	North-West	120	=M144/100
165	West-North	150	=M143/100
166	West	180	=M142/100

Figure 3.8-1 – EXCEL-generated wind rose frequency of occurrence diagram for the wind “from” direction in the ASHPLUME coordinate system



3.9 Number of Waste Packages Intersected Per Eruptive Conduit CDF

The CDF for the number of packages hit per conduit is obtained from CRWMS M&O 2000c (CAL-WIS-PA-000001 Rev01, Section 5.2). CAL-WIS-PA-000001 Rev01 uses EXCEL 97-SR-1 to calculate how many waste packages are intersected for each conduit diameter (ranging from 4.5 – 150m) for 2 extreme cases: 1. If the conduit is centered on the drift; or 2. if the conduit is centered on the pillar between the drifts. For conduits with diameters larger than 90 meters more packages are intersected by centering the conduit on the pillar which allows the conduit to intersect a smaller portion of 2 drifts. CAL-WIS-PA-000001 Rev01 Attachment IV, Section 1.2 (CRWMS M&O 2000c) explains how EXCEL was used to make this calculation. Section 3.14 describes how the underlying CDF for conduit diameter was developed.

3.10 Number of Eruptive Conduits PDF

The number of conduits intersecting the waste is provided by CRWMS M&O 2000d (ANL-MGR-GS-000001 Rev00 ICN01, Table 12a – Primary + Contingency Block Mean Hazard), and CDFs and PDFs for this parameter are developed in CRWMS M&O 2000c (CAL-WIS-PA-000001 Rev01). The probability of zero conduits forming is 22.6%. This probability is normalized out of the resulting PDFs and CDFs so that the distributions cover 1-13 conduits. The zero conduit probabilities have been removed so that all the simulations will result in doses to the critical group. The results are then combined with the probability of zero conduits occurring (0.226); this results in a reduction in the final probability weighted dose values. Accounting for the probability of zero conduits intersecting the waste is done in the post processing of the ASHPLUME code results within the TSPA-SR model.

Table 3.10-1 – Marginal conditional distribution for number of conduits within the Repository Footprint (ANL-MGR-GS-000001 Rev00 ICN01, Table 12a Primary + Contingency Blocks Mean hazard)

Number of Conduits	Final Composite Conditional Probability (PDF)
0	0.226000
1	0.578500
2	0.091000
3	0.039250
4	0.028750
5	0.019000
6	0.008500
7	0.004050
8	0.002100
9	0.001015
10	0.000650
11	0.000450
12	0.000165
13	0.000005

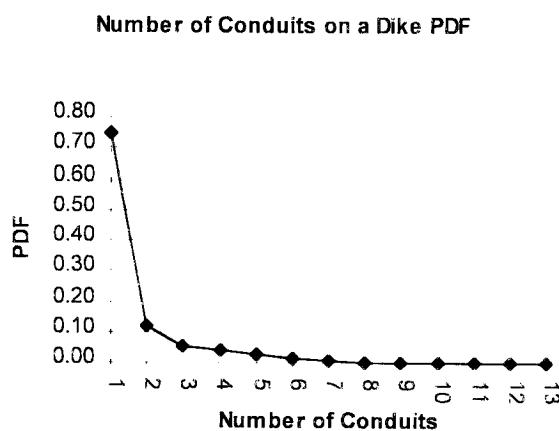
Table 3.10-2 - EXCEL 97-SR-1 calculation for determining the PDF for Number of Eruptive Conduits Normalized to Remove Probability of Zero Conduits

	Number of Conduits	Final Composite PDF	Final Composite Conditional Probability (PDF) Normalized to remove probability for Zero Conduits
Column>	M	N	O
Row			
6	1	0.578500	0.74796
7	2	0.091000	0.11766
8	3	0.039250	0.05075
9	4	0.028750	0.03717
10	5	0.019000	0.02457
11	6	0.008500	0.01099
12	7	0.004050	0.00524
13	8	0.002100	0.00272
14	9	0.001015	0.00131
15	10	0.000650	0.00084
16	11	0.000450	0.00058
17	12	0.000165	0.00021
18	13	0.000005	0.00001
		0.773435	1

Table 3.10-3 - EXCEL formulae used to generate values shown in Table 3.10-2

		Number of Conduits	Final Composite PDF	Final Composite Conditional Probability (PDF) Normalized to remove probability for Zero Conduits
Column>	Row	M	N	O
6	1		0.5785	=N6/0.773435
7	2		0.091	=N7/0.773435
8	3		0.03925	=N8/0.773435
9	4		0.02875	=N9/0.773435
10	5		0.019	=N10/0.773435
11	6		0.0085	=N11/0.773435
12	7		0.00405	=N12/0.773435
13	8		0.0021	=N13/0.773435
14	9		0.001015	=N14/0.773435
15	10		0.00065	=N15/0.773435
16	11		0.00045	=N16/0.773435
17	12		0.000165	=N17/0.773435
18	13		0.000005	=N18/0.773435
			=SUM(N6:N18)	=SUM(O6:O18)

Figure 3.10-1 - EXCEL-generated figure showing the PDF for Number of Eruptive Conduits Normalized to Remove Probability of Zero Conduits PDF



3.11 Event Probability CDF

The probability distribution of igneous event frequency of intersection of a dike with the repository footprint (primary + contingency block) is obtained from CRWMS M&O 2000d (ANL-MGR-GS-000001 Rev00 ICN01, Section 6.5.3.1 and DTN

LA0009FP831811.004). This probability distribution is used within the TSPA-SR model in calculating the expected annual dose for the critical group. The CDF for the igneous event probability is developed using EXCEL 97-SR-1 to normalize the reported PDF, group the normalized PDF into bins containing the average of 5 sequential values, and finally transform the binned PDF into a CDF.

Table 3.11-1 - A portion of the EXCEL spreadsheet used to normalized the PDF for event probability

Column	A	B	C
Row	Frequency	Normalized PDF	Original PDF
6	1.38E-11	8.636E-08	8.64E-08
7	1.41E-11	6.910E-08	6.91E-08
8	1.48E-11	5.527E-08	5.53E-08
9	1.51E-11	3.109E-08	3.11E-08
10	1.55E-11	8.885E-09	8.89E-09
11	1.59E-11	1.500E-08	1.50E-08
12	1.62E-11	3.388E-07	3.39E-07
13	1.66E-11	2.175E-06	2.18E-06
14	1.70E-11	2.724E-08	2.72E-08
15	1.74E-11	2.351E-07	2.35E-07
16	1.78E-11	5.032E-07	5.03E-07
17	1.82E-11	7.338E-07	7.34E-07

Table 3.11-2 - EXCEL formulae used to generate values shown in Table 3.11-1

Normalized Frequency	PDF	Original PDF
0.0000000000138	=C6/\$C\$474	0.00000008636
0.00000000001413	=C7/\$C\$474	0.0000000691
0.00000000001479	=C8/\$C\$474	0.00000005527
0.00000000001514	=C9/\$C\$474	0.00000003109
0.00000000001549	=C10/\$C\$474	0.00000008885
0.00000000001585	=C11/\$C\$474	0.000000015
0.00000000001622	=C12/\$C\$474	0.0000003388
0.0000000000166	=C13/\$C\$474	0.000002175
0.00000000001698	=C14/\$C\$474	0.0000002724
0.00000000001738	=C15/\$C\$474	0.0000002351
0.00000000001778	=C16/\$C\$474	0.0000005032
0.0000000000182	=C17/\$C\$474	0.0000007338

Note that the original probability distribution summed to 1.00000293 which is the EXCEL summed formulae \$C\$474.

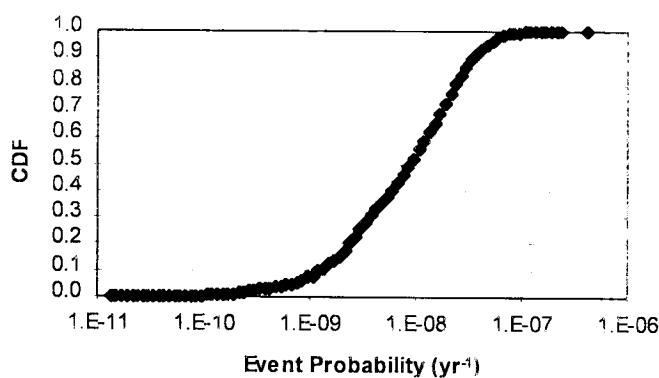
Table 3.11-3 – A portion of the EXCEL spreadsheet used to bin the PDF and calculate the CDF for event probability

Column	G	H	I
ROW	Frequency	Binned PDF	CDF
6	1.3800E-11	8.63597E-08	8.6360E-08
7	1.5080E-11	1.79344E-07	2.6570E-07
8	1.6992E-11	3.27933E-06	3.5450E-06
9	1.9064E-11	1.79409E-06	5.3391E-06
10	2.1392E-11	3.55939E-06	8.8985E-06
11	2.4002E-11	5.89498E-06	1.4794E-05
12	2.6928E-11	4.71879E-05	6.1981E-05
13	3.0214E-11	1.99779E-04	2.6176E-04
14	3.3900E-11	1.79609E-05	2.7972E-04
15	3.8038E-11	2.71479E-05	3.0687E-04
16	4.2682E-11	3.70909E-05	3.4396E-04
17	4.7888E-11	4.25369E-05	3.8650E-04

Table 3.11-4 - EXCEL formulae used to generate values shown in Table 3.11-3

Binned		
Frequency	PDF	CDF
=A6	=B6	=H6
=AVERAGE(A7:A11)	=SUM(B7:B11)	=H7+I6
=AVERAGE(A12:A16)	=SUM(B12:B16)	=H8+I7
=AVERAGE(A17:A21)	=SUM(B17:B21)	=H9+I8
=AVERAGE(A22:A26)	=SUM(B22:B26)	=H10+I9
=AVERAGE(A27:A31)	=SUM(B27:B31)	=H11+I10
=AVERAGE(A32:A36)	=SUM(B32:B36)	=H12+I11
=AVERAGE(A37:A41)	=SUM(B37:B41)	=H13+I12
=AVERAGE(A42:A46)	=SUM(B42:B46)	=H14+I13
=AVERAGE(A47:A51)	=SUM(B47:B51)	=H15+I14
=AVERAGE(A52:A56)	=SUM(B52:B56)	=H16+I15
=AVERAGE(A57:A61)	=SUM(B57:B61)	=H17+I16

Figure 3.11-1 - EXCEL-generated figure showing the CDF for event probability.



3.12 Number of Packages Intersected Zone 1 CDF

The CDF for the number of packages intersected in Zone 1 is taken from CRWMS M&O 2000c (CAL-WIS-PA-000001 Rev01, Section 5.3, Table III-6, and Attachment IV).

3.13 Number of Packages Intersected – Combined Zone 1 and 2 CDF

The CDF for the number of packages intersected in Zone 1 and 2 combined is taken from CRWMS M&O 2000c (CAL-WIS-PA-000001 Rev01, Section 5.3, Table III-7, and Attachment IV).

3.14 CDF for Conduit Diameter

Crystal Ball Version 4.0 is used as a pre-processor in EXCEL 97-SR-1 to develop the PDF for conduit diameter. In this application, Crystal Ball used in a trial and error fashion to simulate a log-normal distribution that fits the specifications of a minimum value of 4.5 m, a median value of 50 m, and a maximum of 150 m using the Crystal Ball log-normal distribution function in the Distribution Gallery. The trial and error procedure varies the input values for the mean and standard deviation of the distribution, until the simulated log-normal distribution output approximates the desired log-normal specifications.

After a simulated log-normal distribution that approximated the given specifications was selected, EXCEL was used to group the raw count simulated probabilities into bins (i.e. 4.5 m – 10 m, 10 m – 20 m, 20 m - 30 m, etc) and calculate the average probability for each bin. The average probability for a bin was then assigned to the minimum conduit diameter in the bin range. EXCEL was then used to calculate the CDF for the selected PDF.

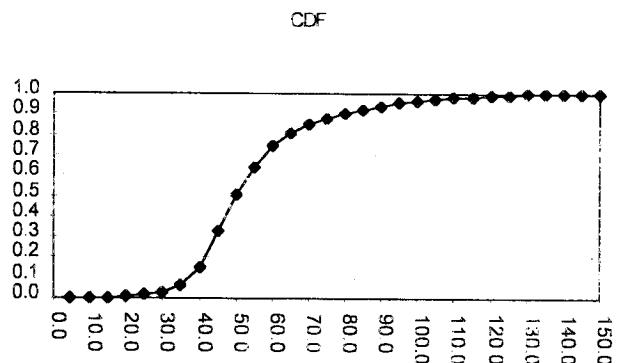
Table 3.14-1 – EXCEL values for the PDF and CDF for conduit diameter.

COLUMN >	K	L	M
ROW	Conduit Diameter	PDF	CDF
8	4.5	0.0004	0
9	10	0.0018	0.0004
10	15	0.0044	0.0022
11	20	0.0079	0.0066
12	25	0.0132	0.0145
13	30	0.0346	0.0277
14	35	0.0919	0.0623
15	40	0.1720	0.1541
16	45	0.1747	0.3262
17	50	0.1405	0.5008
18	55	0.1054	0.6413
19	60	0.0615	0.7467
20	65	0.0395	0.8082
21	70	0.0299	0.8477
22	75	0.0250	0.8776
23	80	0.0211	0.9026
24	85	0.0176	0.9237
25	90	0.0136	0.9412
26	95	0.0105	0.9549
27	100	0.0079	0.9654
28	105	0.0066	0.9733
29	110	0.0054	0.9799
30	115	0.0044	0.9853
31	120	0.0036	0.9897
32	125	0.0026	0.9933
33	130	0.0018	0.9960
34	135	0.0011	0.9978
35	140	0.0007	0.9989
36	145	0.0004	0.9996
37	150	0.0000	1.0000
38			
39	SUM	1.0000	

Table 3.14-2 - EXCEL formulae used to generate values shown in Table 3.14-1

COLUMN >	K	L	M
ROW	Conduit Diameter	PDF	CDF
8	4.5	0.00043909721612365	0
9	10	0.0017563888644946	=L8+M8
10	15	0.0043909721612365	=L9+M9
11	20	0.0079037498902257	=L10+M10
12	25	0.0131729164837095	=L11+M11
13	30	0.0346008606305436	=L12+M12
14	35	0.0918591376130675	=L13+M13
15	40	0.172038289277246	=L14+M14
16	45	0.174672872573988	=L15+M15
17	50	0.140511109159568	=L16+M16
18	55	0.105383331869676	=L17+M17
19	60	0.061473610257311	=L18+M18
20	65	0.0395187494511284	=L19+M19
21	70	0.0298586106964082	=L20+M20
22	75	0.0250285413190481	=L21+M21
23	80	0.0210766663739352	=L22+M22
24	85	0.017563888644946	=L23+M23
25	90	0.0136120136998331	=L24+M24
26	95	0.0105383331869676	=L25+M25
27	100	0.00790374989022569	=L26+M26
28	105	0.00658645824185478	=L27+M27
29	110	0.00544480547993331	=L28+M28
30	115	0.00439097216123652	=L29+M29
31	120	0.00360059717221395	=L30+M30
32	125	0.00263458329674193	=L31+M31
33	130	0.00184420830771936	=L32+M32
34	135	0.00114165276192146	=L33+M33
35	140	0.000702555545797789	=L34+M34
36	145	0.000351277772898673	=L35+M35
37	150	0	=L36+M36
38			
39	SUM	=SUM(L8:L37)	

Figure 3.14-1 - EXCEL-generated figure showing the CDF for conduit diameter.



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